A COMPARISON OF CLINICAL, ROENTGEN, AND MICROSCOPICAL FINDINGS IN FIFTEEN CASES OF INFECTED VITAL PULPS[1]

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I. INTRODUCTION

In a recent paper[2] I published the results of a bacterial investigation of infected vital dental pulps, and showed that chronic pulp infection is generally a streptococcus disease. I also emphasized the fact that the infected vital pulp is often the cause of somatic disease, and that its removal gives prompt relief of the systemic condition. Among the conclusions of the paper were these:

"(1) All teeth that have been painful, or very sensitive to hot food, should be carefully investigated, because such teeth often have infected vital pulps.

"(2) The fact that a tooth reacts positively to so-called vitality tests, or is sensitive when opened up, or painful when the pulp is exposed, does not prove that the pulp is not infected.

"(3) A more careful study of the roentgen picture is necessary. If a large number of root-filled teeth, with or without infection, are present, they often distract attention from the small changes giving indirect roentgen evidence of an infected vital pulp."

In Oral Roentgenology, the first edition of which was published in

[1] Read at a meeting of the First District Dental Society of the State of New York, New York Academy of Medicine, March 4, 1929.

[2] Thoma: The infected vital dental pulp; an important focus of infection. *Journal of Dental Research*, 1928, viii, p. 529.

1917, I pointed out the value of the roentgen examination in the diagnosis of pulp infection. Today I feel very strongly that the roentgen picture is the most reliable means of making a diagnosis of pulp infection in a vital tooth. It is true that it is often necessary to take several views of a suspected section, but it should be possible in almost every case to demonstrate (*a*) an etiological factor, such as deep primary or secondary caries, or (*b*) secondary changes, such as an extension of the inflammation into the periapical tissue, or (*c*) both.

The finding of an etiological factor directs attention to a tooth that often should be further investigated, either by means of additional roentgen pictures or by clinical methods. Etiological factors are seen as small defects representing secondary caries, under fillings and crowns and extending close to the pulp canal. In rarer instances, deep pockets may be seen on the sides of teeth, or the periapical infection may extend to the apex of a neighboring tooth with a normal pulp. Sometimes an impacted third molar may cause decay on the distal side of a second molar, producing pulp infection. Defects in the crowns of teeth are not always easily demonstrated in the ordinary roentgen film, and it may be necessary to use the bite-wing method or an horizontal angle of exposure on an ordinary film.

The secondary changes in the periapical tissue are evidence, almost *per se*, of pulp infection. In the beginning the enlargement of the periapical space, produced by the increased size of the inflamed peridental membrane, is so slight that it is visible only in a roentgen picture of good quality and taken at a favorable angle. A positive diagnosis often can be made only when roentgen pictures also demonstrate the cause of the condition, or when there is confirmation by clinical examination (symptoms). In cases of longer standing, the periapical evidence is well marked and unmistakable.

In taking the history, it is often possible to get important information that is helpful in making a diagnosis. Questions should be so directed as to bring back to the patient's mind half-forgotten minor disturbances. Among these are sharp pains of temporary duration, or dental neuralgia of more or less lasting character. Reflex symptoms occur quite frequently in chronic pulpitis, but are by no means typical of the disease. Pain may have been caused by hot food. Specially painful experiences during past dental operations may be remembered.

Sometimes a patient knows that a cavity was extremely deep, or that the pulp had almost been exposed and capped. The dentist may have said he did not dare to remove all the decay, or the patient may remember that a tooth had been aching after it was filled but the pain had later disappeared. Such information often may be found valuable, confirming the x-ray findings.

In order to correlate clinical findings, changes indicated in the roentgen picture, and pathological changes as seen under the microscope, I have undertaken to study a number of cases from these various points of view. The results may be divided into five groups:

(A) Cases with history of pulp capping.
(B) Cases showing no periapical involvement in the roentgen picture
(C) Cases showing slight periapical change in the roentgen picture
(D) Cases showing marked periapical change in the roentgen picture
(E) Cases caused by periodontoclasia

The summaries and illustrations of these cases are presented on the succeeding pages, where the illustrations are placed opposite the summaries whenever possible, to facilitate comparisons.

II. CASES

Case 1. Mr. T. A. Ro—. Right inferior second bicuspid.[3] *Group A*

History. The patient, feeling poorly, had all teeth roentgenographed by his dentist. He complained of the right inferior second bicuspid, which had given slight discomfort at irregular intervals. The tooth had been excavated and capped six months before with zinc oxide and eugenol. The dentist sent the patient to have the tooth extracted.

Roentgen findings. Two fillings showed in the mesial and distal sides of the tooth. The mesial filling seems to be in close contact with the pulp canal. The periapical tissue shows no recognizable changes. (*Fig. 1*)

Microscopic changes. An actual exposure is visible in the mesial part of the tooth. The pulp presents an ulcerating surface, with exudate in the upper part of the canal. Beneath the ulcerating surface is inflammatory pulp tissue, with so-called "calcium glands." Farther down there is a pulp abscess of long standing—it is surrounded by a fibrous capsule. The remainder of the pulp shows hyperemia and injection of small round-cells. (*Figs. 2, 3,* and *4*)

Conclusions. This tooth must have been in a state of chronic inflammation before capping. The old abscess, with symptoms previous to capping, supports this opinion. No doubt toxins, produced in this pulp, were being absorbed.

[3] In the legends under the figures, abbreviations on a conventional plan are used to indicate the individual tooth. Thus, in this instance, "R. I. 5" signifies right inferior second bicuspid.

FIG. 1. Case 1. Roentgen picture of R. I. 5.

FIG. 2. Case 1. Photomicrograph of R. I. 5. *M.*—mesial side. *D.*—distal side. See also *figs. 3* and *4*.

FIG. 3. Case 1. High magnification of the upper square in *fig. 2.*

FIG. 4. Case 1. High magnification of the lower square in *fig. 2.*

Case 2. Miss P. Ha—. Right inferior second molar. Group A

History. The patient's dentist stated that the tooth had been filled three and one half years previously, with a capping under the filling over a nearly exposed pulp. Roentgen examination six months later disclosed no trouble with the tooth. At present severe pain is caused by percussion on the tooth. The tooth was again roentgenographed and tested as to vitality. It gave a marked response. The patient was then referred to me for extraction of the tooth.

Roentgen findings. A deep filling is seen. Only very slight periapical changes occurred. The symptoms and history of capping are more conclusive in making a diagnosis than the roentgen picture. (*Fig. 5*)

Microscopic findings. The place where the pulp appeared to be nearly exposed is not visible in this section. The pulp shows two old chronic abscesses, as evidenced by the oval spaces, surrounded by a fibrous connective-tissue capsule. The main pulp is partly necrotic. But in the pulp canals there is vitality, with hyperemia and inflammatory infiltration of the tissue. (*Fig. 6*)

Conclusions. It might be assumed that, at the time of the capping, the pulp was already infected, or the infection developed after the treatment. The symptoms no doubt were caused by a decomposition of the necrotic tissue, and infection of the vital tissue in the root canals.

FIG. 5. Case 2. Roentgen picture of R. I. 7.

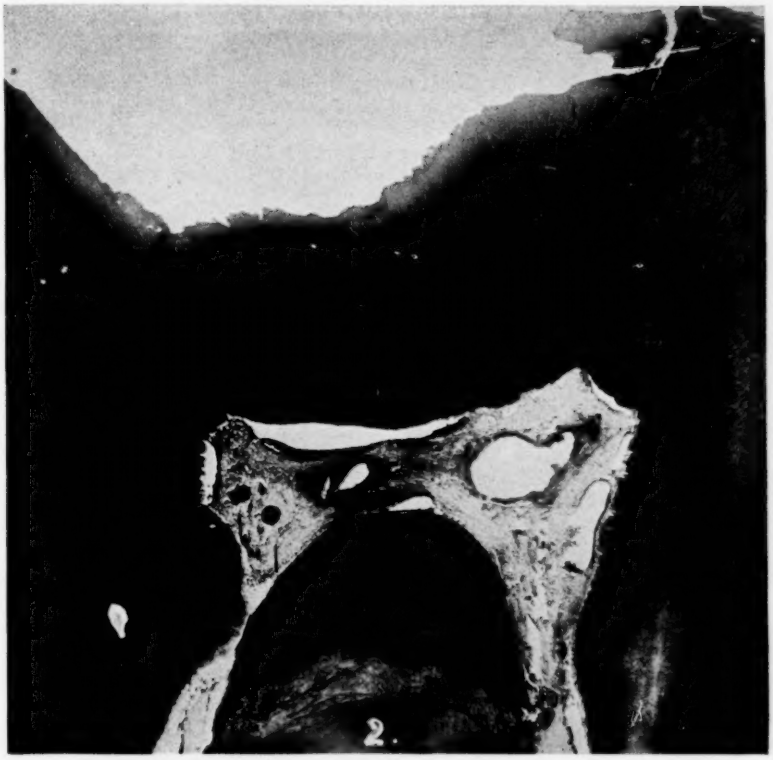

FIG. 6. Case 2. Photomicrograph of R. I. 7.

Case 3. Miss A. Br—. Right inferior second bicuspid. Group A

History. The tooth had been capped some time ago; the patient did not remember when. There were no symptoms.

Roentgen findings. A diagnosis of pulp infection was based on (a) the etiological factor in the deep filling, with less opaque substance directly over the pulp chamber, and on (b) the secondary changes at the apex—a well marked granuloma. (*Fig. 7*)

Microscopic findings. There is a perforation in the roof of the pulp canal, and infection in the dentinal canals in this region, probably owing to secondary caries. The pulp shows complete necrosis after general fibrinous infiltration. The granuloma at the apex exhibits small-cell infiltration, and has the regular fibrous capsule. (*Figs. 7* and *8*)

Conclusion. The pulp was probably infected when it was capped and filled.

FIG. 7. Case 3. Photomicrograph and roentgen picture of R. I. 5.

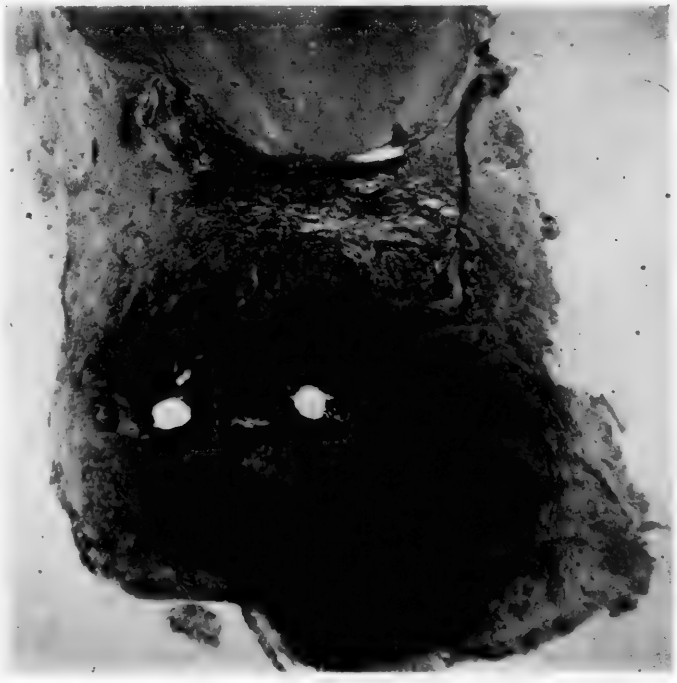

FIG. 8. Case 3. Photomicrograph of apex of R. I. 5, with granuloma.

Case 4. Mr. T. F. Ha—. Left superior central incisor. Group B

History. The patient has never had any discomfort from the tooth; the condition was noted in a routine roentgen examination.

Roentgen findings. A circular radiopaque area in the crown is due to a filling on the labial surface. There is evidence of caries on the distal side, and deeper caries on the mesial side of the crown, indicating an etiological factor; no change at the apex. A diagnosis of pulp disease may, therefore, be questioned. (*Fig. 9*)

Microscopic findings. The cavity on the distal side shows deeply infected dentine, but no stimulation of adventitious or secondary dentine formation. On the mesial side, however, excessive adventitious dentine obliterates the pulp canal to the median line. The pulp shows hyperemia of vessels, and normal nerves. In the region of the neck of the tooth there is a localized area of round-cell infiltration, the first step in abscess formation. (*Figs. 10, 11* and *12*)

Conclusions. This specimen shows a very early stage of pulp infection centralized in the upper or coronal third of the tooth. The reaction in the surrounding pulp tissue is very mild, is entirely absent in the apical part of the root, and certainly does not affect the periapical tissue, therefore giving no roentgen evidence in periapical structures.

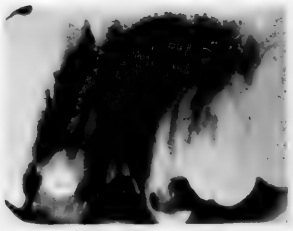

FIG. 9. Case 4. Roentgen picture of L. S. 1.

FIG. 10. Case 4. Photomicrograph of L. S. 1. See also *figs. 11* and *12*.

FIG. 11. Case 4. High magnification of tissue in the square in *fig. 10*. See also *fig. 12*.

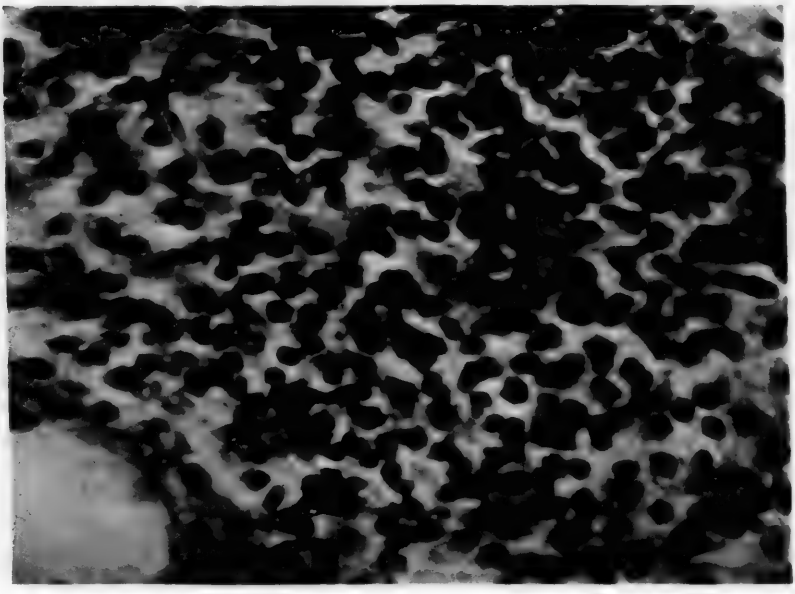

FIG. 12. Case 4. Higher magnification of tissue in the square in *fig. 10*.

Case 5. Mr. L. Hu—. Right inferior second molar. Group B

History. For three weeks the patient has been aware of deafness in the right ear. There were no dental symptoms.

Roentgen findings. Routine examination showed secondary caries under the filling on the distal side. The periapical region was normal. (*Fig. 14*)

Microscopic findings. The dental canals on the mesio-occlusal side were deeply infected. On the distal side there was a cavity with broken down dentine. Opposite both places there was a deposit of adventitious dentine. The distal cornu also shows infected dentinal canals. There was edemic infiltration in the distal cornu and well-marked diffuse round-cell infiltration in the pulp chamber; very little infiltration in the tissue of the root canals, but presence of calcareous degeneration. A culture was made from the apical part of the root canal (distal). (*Figs. 13* and *15*)

Bacterial examination. Bacterial examination shows the presence of streptococcus and staphylococcus.

Conclusions. While this case exhibits definite pulpitis and infection in the distal root canal, no well-marked reaction has occurred; at least it could not be demonstrated in the roentgen picture.

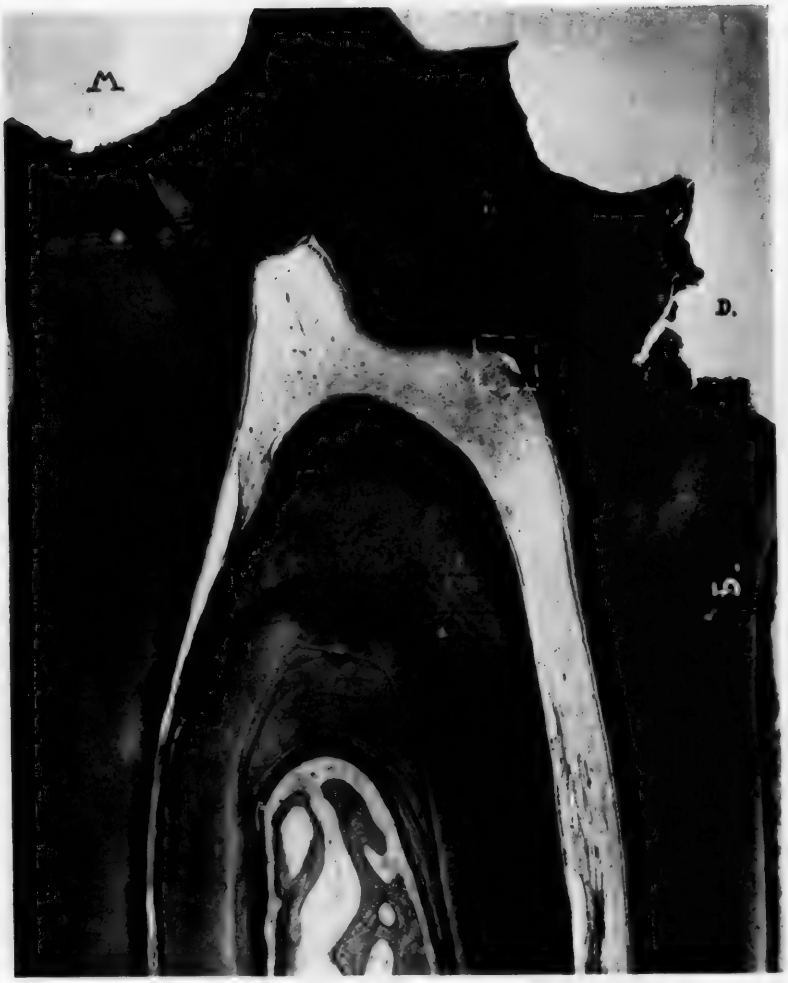

FIG. 13. Case 5. Photomicrograph of R. I. 7. See *fig. 15*.

FIG. 14. Case 5. Roentgen picture of R. I. 7.

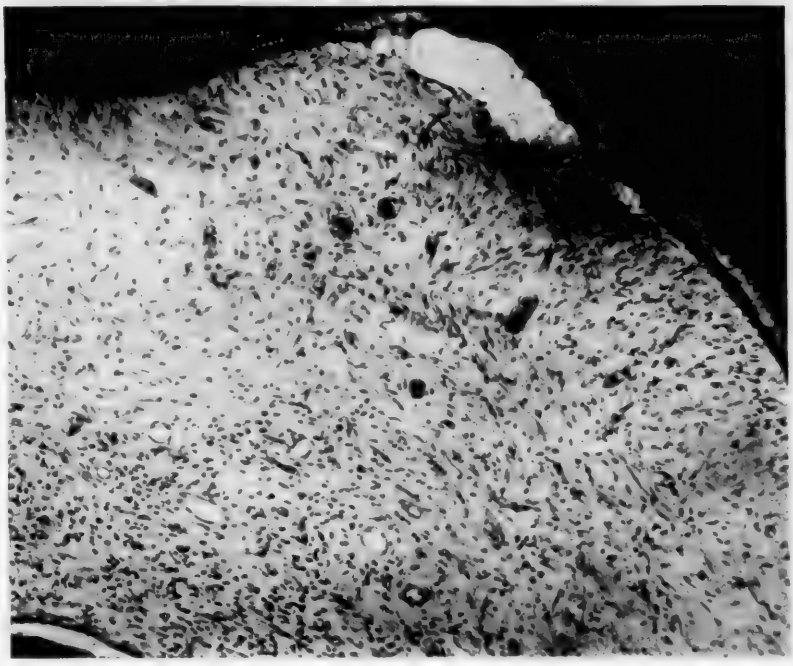

FIG. 15. Case 5. High magnification of a portion of the right side of the pulp chamber. See the square in *fig. 13*.

Case 6. Mr. P. E. Wi—. Left inferior third molar. Group B

History. The patient felt pain in the left lower incisor region. His dentist tested the teeth and removed the pulp from the left inferior central incisor without relief of symptoms. Pain was relieved after extraction of the left lower third molar.

Roentgen examination. Pictures were taken from different angles. No caries is visible in the first film. In the second film, secondary caries is indicated under the distal part of the filling in the left lower third molar. There are no perceptible changes in the periapical tissues. (*Fig. 16*)

Microscopic findings. Close proximity of the cavity to the pulp chamber is evident. Large masses of erythrocytes are seen in the tissues owing to diapedesis. There is diffuse infiltration of round cells in the pulp chamber and upper part of the root canals. The apical part of the root canals is normal except for hyperemia of the vessels. (*Figs. 16* and *17*)

Conclusions. The diagnosis was made by the finding of deep-seated secondary caries. Note that this is visible in only one of the roentgen films, illustrating the importance of careful investigation.

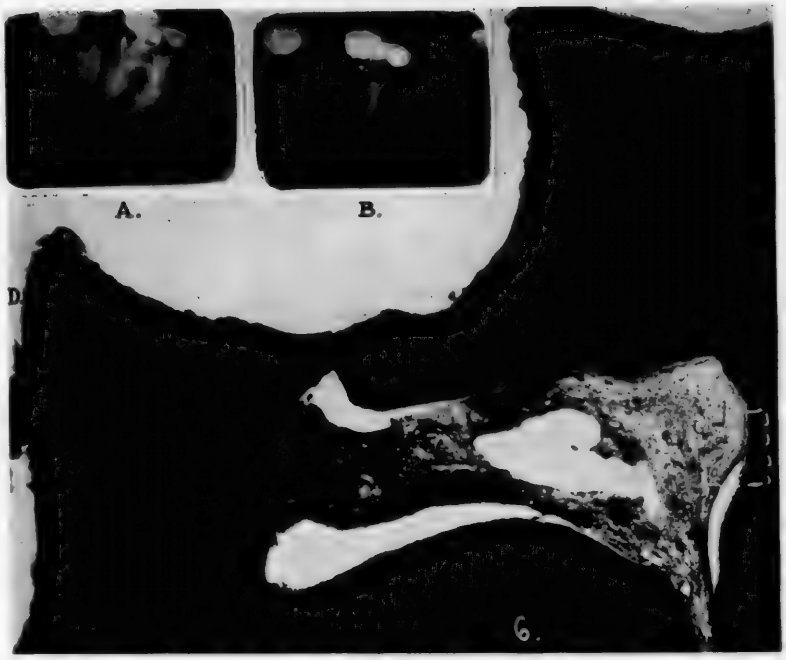

FIG. 16. Case 6. Photomicrograph of L. I. 8. Inserts: *A*—First roentgen picture. *B*.—Roentgen picture showing secondary caries under filling in L. I. 8.

FIG. 17. Case 6. High magnification of a portion of the tissue in the square in *fig. 16*.

Case 7. Mr. P. H. Ba—. Left inferior first molar. Group C

History. The patient complained of occasional pain in the left side of the mandible. A vitality test was normal. The patient was relieved after extraction of the left inferior first molar.

Roentgen examination. The inlay is very near the pulp on the distal cornu. The periapical tissue around the mesial root is abnormal. Diagnosis: pulp infection. (*Fig. 18*)

Microscopic examination. The close proximity of the inlay to the wall of the pulp chamber apparently stimulated the formation of adventitious dentine and other calcified deposit, which finally caused an almost complete obliteration of the pulp chamber and upper part of the distal root canal. A few concentrically arranged pulp stones have been incorporated in the mass. Several cross sections of canals containing pulp tissue are visible. They contain nerve bundles closely crowded together, and a few vessels. The round-cell infiltration indicates chronic inflammation. (*Fig. 19*)

Conclusions. The irritation from a large inlay stimulated excessive formation of adventitious dentine. The pulp tissue, though infected, is well supplied with nerves conveying sensation.

FIG. 18. Case 7. Roentgen picture of L. I. 6.

FIG. 19. Case 7. Photomicrograph of L. I. 6.

Case 8. Miss A. J Wa—. Right inferior first molar. Group C

History. The patient complained of a swollen face and pain in the right side of the lower jaw.

Roentgen examination. There is evidence of caries (disto-occlusal) under the filling, and very slight change in the periapical structure. Diagnosis: pulp infection in the right inferior first molar. (*Fig. 20*)

Microscopic examination. Infection apparently spread from the carious dentine to the pulp. Only a thin layer of adventitious dentine has been formed. Many odontoblasts have become imbedded in the dentinoid substance. There are two well circumscribed abscesses, and a number of denticles and so-called calcium glands. The pulp shows very marked general round-cell infiltration; the vessels are gorged with erythrocytes, and lymphocytes are numerous. (*Fig. 21*)

Conclusion. The pulp shows chronic infection, with pulp abscesses.

FIG. 20. Case 8. Roentgen picture of R. I. 6.

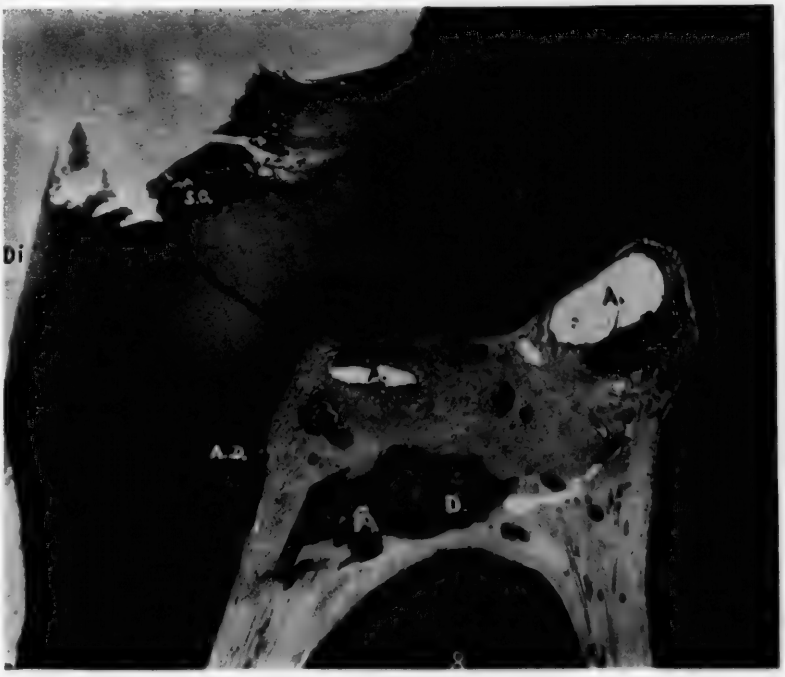

FIG. 21. Case 8. Photomicrograph of R. I. 6. *AD.*—Adventitious dentine. *A.*—Abscess. *D.*—Denticle. *Di.*—Distal side.

Case 9. Mrs. J. W. An—. Right inferior third molar. Group C

History. The patient complained of pain in the right lower molars. There were two large cavities in the distal part of the second molar and the mesial part of the third.

Roentgen examination. The roentgen picture shows a very deep cavity in the right lower third molar, and decided changes in the periapical tissue. (*Fig. 22*)

Microscopic examination. Deep caries is seen in the mesial part of the crown. The infected dentinal canals extend into adventitious dentine in the mesial cornua of the pulp chamber. The pulp shows hyperemia, vacuoles containing serum, and an abscess in the mesial part with round-cell infiltration. The peridental membrane attached to the apex exhibits marked round-cell infiltration. (*Fig. 23*)

Conclusion. There was a pulp abscess, caused by caries, the infection extending into the periapical tissue.

FIG. 22. Case 9. Roentgen picture of R. I. 8.

FIG. 23. Case 9. Photomicrograph of R. I. 8.

Case 10. Mrs. J. L. Ma—. Left inferior second bicuspid. Group C

History. The patient complained of pain. A vitality test showed the left inferior cuspid +, the left inferior second bicuspid +, and the left inferior first bicuspid −. The patient, however, felt that the left inferior second bicuspid was giving the discomfort, because it was slightly sensitive to percussion.

Roentgen examination. The filling in the distal part of the left inferior second bicuspid extends very close to the pulp. There is, however, no evidence of secondary caries. A slight change in the periapical tissue, with symptoms localized in this tooth, leads to diagnosis of pulp infection. (*Fig. 24*)

Microscopic findings. The depth to which the distal filling extended is plainly visible. The adventitious dentine opposite the defect shows infected dentinal canals. The amount of adventitious dentine opposite the mesial filling is small. The terminal part of the pulp exhibits reticular atrophy. Opposite the infected dentine, a connective-tissue membrane encapsulates an old abscess cavity. The vital pulp-tissue below this shows reticular atrophy of the odontoblastic layer, calcareous deposits, and inflammatory infiltration. Vacuoles are present containing serum. The peridental membrane attached to the apex also shows round-cell infiltration. (*Figs. 24* and *25*)

Conclusions. The dentine remaining under the filling apparently was infected, causing pulp abscess and secondary changes. The infiltration of the peridental membrane caused increase in its size, visible in the roentgen picture.

FIG. 24 FIG. 25

FIG. 24. Case 10. Photomicrograph, and roentgen picture, of L. I. 5. See *fig. 25.*
FIG. 25. Case 10. Higher magnification of tissue in the square in *fig. 24.*

Case 11. Mr. M. Si—. Right superior first molar. Group C

History. On account of general toxemia and ill health, the patient had a general roentgen examination of the teeth. There was no dental discomfort or pain.

Roentgen examination. Secondary caries, under the occlusal filling is plainly visible; also slight change in the periapical area. (*Fig. 26*)

Microscopic findings: bucco-palatal section. (Shrinkage of the pulp causes an artificial space on the palatal side of the pulp canal.) A small layer of adventitious dentine is visible. Infected dentinal canals extend close to the pulp. There is abscess formation in the palatal part of the pulp, with very marked inflammatory infiltration extending into the palatal root-canal. The periapical tissue attached to the tooth also shows marked round-cell infiltration. (*Fig. 27*)

Bacterial examination. The apex of the palatal root, cut off for bacterial examination, shows a gram positive streptococcus, identified as streptococcus viridans.

Conclusion. Secondary caries is the cause of the pulp abscess, which produced secondary changes in the peridental membrane.

FIG. 26. Case 11. Roentgen picture of R. S. 6.

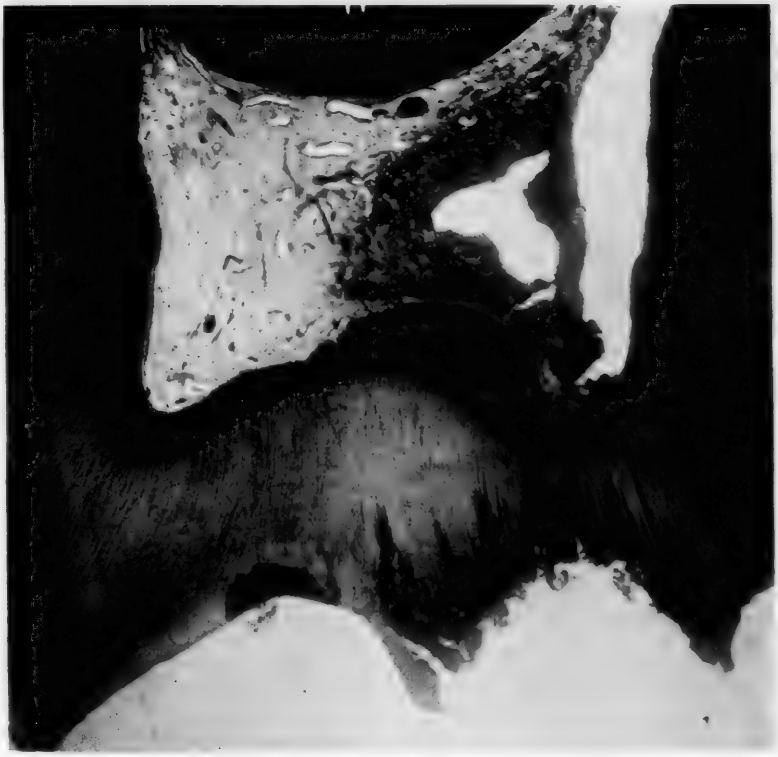

FIG. 27. Case 11. Photomicrograph of R. S. 6. Bucco-palatal section.

Case 12. Mrs. W. McNe—. Left lower first bicuspid. Group D

History. The patient had been suffering for a short time from rheumatism in the toes and arms. General roentgen examination was made. The abscess seen in the roentgen picture on the left inferior first bicuspid became acute following roentgen exposure. The tooth was extracted three days later.

Roentgen examination. A large disto-occlusal filling is seen. There is no visible evidence of caries. The large radiolucent area at the apex indicates periapical infection. This leads to a diagnosis of pulp infection. (*Fig. 28*)

Microscopic examination. The filling evidently extended very near the pulp canal. Adventitious dentine occurs in fair amount. Infected dentinal canals extend to the adventitious dentine. The pulp shows diffuse infiltration, with abscess formation. (*Fig. 29*)

Bacterial examination. The apex was cut off for bacterial examination, which showed presence of staphylococcus albus.

Conclusions. Chronic pulpitis caused periapical infection, probably of long standing. It was activated by the x-ray exposure, producing acute inflammation.

FIG. 28. Case 12. Roentgen picture of L. I. 4.

FIG. 29. Case 12. Photomicrograph of L. I. 4.

Case 13. Master K. Ma—. Left inferior second temporary molar. Group D

History. The patient, a boy five years old, presented a swollen face after having a filling put into the left inferior second temporary molar. The tooth was very sore, with swelling on the buccal gingiva.

Roentgen findings. There are three fillings in the left inferior second temporary molar. The mesio-occlusal one is very close to the cornua of the pulp. A dark area around the mesial root indicates infection of the pulp and periapical tissue. (*Fig. 30*)

Microscopic findings. There is evidence of caries in two places: first, from the occlusal surface; second, from the mesio-occlusal side, where there is very little dentine between pulp and filling, and it consists chiefly of adventitious dentine, which has become infected. The pulp in the pulp chamber shows evidence of purulent infection. There are remains of one large and two smaller abscess cavities, but the bulk of the pulp tissue, including nerves, vessels, and odontoblasts, has been destroyed. The necrosis of the cells is indicated by the poor staining quality of the tissue. In several places, clumps of a few living round cells contrast with the remaining tissue. In the root canals the tissue is vital, hyperemic, and in a state of violent acute inflammation. The predominant cells are polymorphonuclear leucocytes. These are seen also in the vessels in large numbers. There is evidence of lacunar absorption of the dentine in the apical part of the root canal as well as on the outer surface of the root. Here the lacunae contain many osteoblasts, aiding in the disposal of the calcified tissue. None, however, could be found in the inside of the tooth. The infiltration of the peridental tissues shows only large numbers of polymorphonuclear leucocytes high up in the bifurcation of the roots. Near the apex, the inflammatory cells are of the mononuclear types. (*Figs. 31, 32,* and *33.*)

Conclusions. This specimen seems to show the normal process of pulp absorption coexistent with chronic abscess in the pulp, but superseded by acute pulpitis, which apparently started when the cavity was closed with a filling.

FIG. 30. Case 13. Roentgen picture of L. I. T. 5.
FIG. 31. Case 13. Photomicrograph of L. I. T. 5. See *figs. 32* and *33*.

FIG. 32. Case 13. High magnification of tissue shown in the square in *fig. 31*.

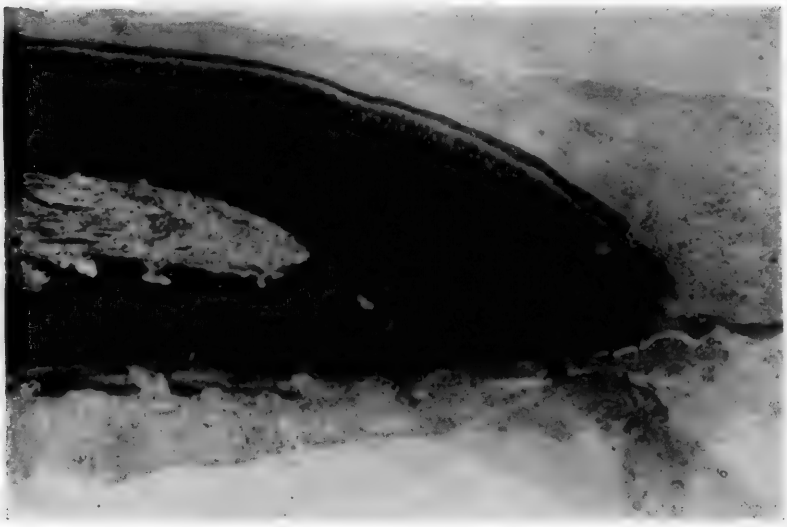

FIG. 33. Case 13. Higher magnification of the root apex of L. I. T. 5, shown at X in *fig. 31*. Here the right side in *fig. 31* is at the top.

Case 14. Mr. E. H. An—. Left superior second molar. Group E

History. The left superior second molar was sensitive to percussion; the gingiva was red and inflamed. There was evidence of periodontoclasia on other teeth. The left superior first molar was extracted some years before because of alveoloclasia, involving especially its distal side.

Roentgen examination. Roentgen pictures taken in May, 1923, indicate infection due to alveoloclasia between the left upper first and second molars. The left upper first molar was extracted and a bridge constructed. The infection continued on the left upper second molar, subsequently reaching the apex of the tooth, as may be seen in the second roentgen picture taken two years later. (*Fig. 34*)

Microscopic findings. The dentine presents no evidence of carious infection; the pulp canal is intact. The pulp shows diapedesis of erythrocytes, formation of vacuoles on the surface, and very marked infiltration. The mononuclear cells predominate, but many polymorphonuclear leucocytes are present; also some pulp stones and other calcium deposits. Inflammation is also evidenced in the pulp canals and apical tissue. The bone tissue in the bifurcation of the roots has been replaced by inflammatory tissue, and the marrow spaces of the alveolar bone show decided infiltration. (*Figs. 35* and *36*)

Conclusions. The infection, due to periodontoclasia apparently, reached the pulp from the apex and caused pulpitis. There is no evidence of access through the crown.

FIG. 34. Case 14. Roentgen pictures of L. S. 7; interval, two years.

FIG. 35. Case 14. Photomicrograph of L. S. 7. See *fig. 36*.

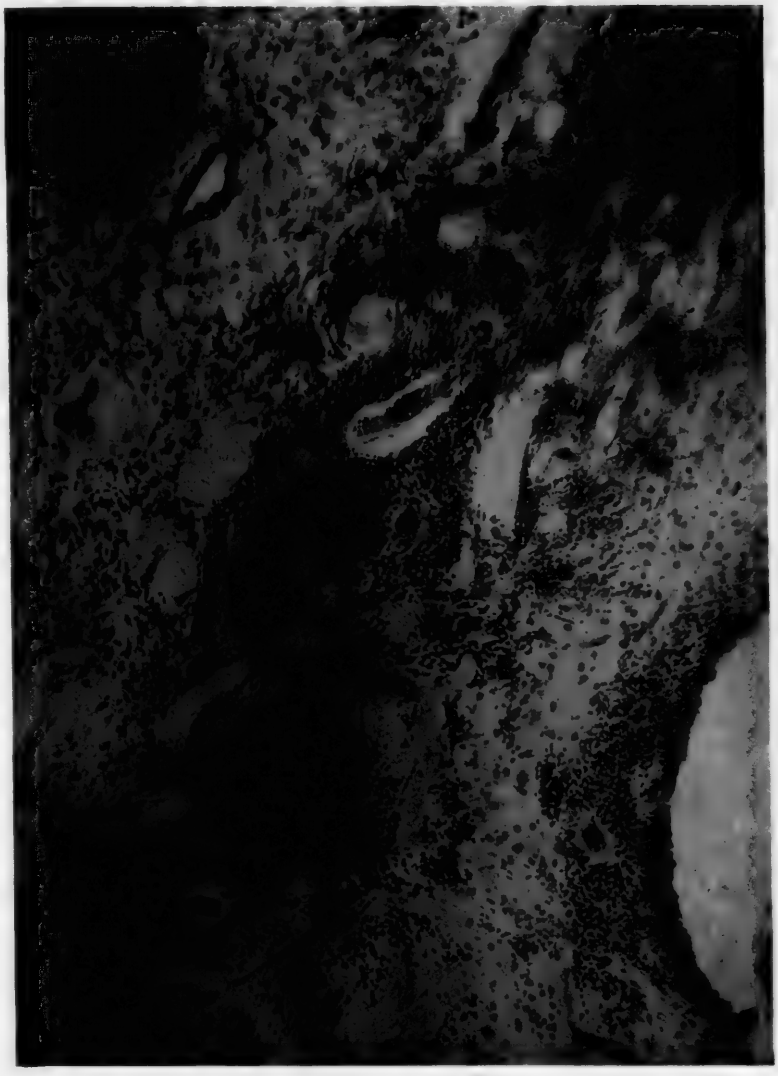

FIG. 36. Case 14. High magnification of tissue in the square in *fig. 35*. Note that the left lower corner in *fig. 35* shows in the right corner here.

Case 15. Mrs. H. La—. Right inferior second molar. Group E

History. The patient was suffering from arthritis, complaining also of soreness of the right inferior second molar. Examination of the teeth showed evidence of periodontoclasia.

Roentgen examination. There is evidence of alveoloclasia between the right lower second and third molars in film A, taken four years ago. In film B, just taken, the distal root appears entirely involved; there is a slight shadow at the mesial root. The cervical margin of the filling on the distal side shows an imperfect condition. (*Fig. 38*)

Microscopic examination. At the periphery of the crown, the dentine shows evidence of decalcification, but there is no actual caries except at the cervical part of the tooth. Both mesially and distally there is an area showing infected dentinal canals, but the defect is not deep seated. Around the entire pulp canal there is a liberal deposit of secondary dentine, in structure similar to the primary dentine. This may have been caused by the large restoration placed on the tooth more than four years ago. The distal part of the pulp shows reticular atrophy, especially adjoining an irregular layer of adventitious dentine opposite the area of cervical caries. The pulp contains the slightest amount of diffuse round-cell infiltration, with marked hyperemia in the apical part of the roots. (*Figs. 37* and *39*)

Conclusion. Periodontoclasia, reaching the distal apex, produced hyperemia and only slight inflammation of the pulp.

FIG. 37. Case 15. Photomicrograph of R. L 7. See *fig. 39.*

FIG. 38. Case 15. Roentgen pictures of R. I. 7; interval, 4 years.

FIG. 39. Case 15. High magnification of tissue in the square in *fig. 37*.

III. SUMMARY

It is interesting to note that, in the fourteen cases of adult patients, the pulp infection was of the chronic type of inflammation. The symptoms were generally indefinite and only occasionally experienced, and the microscopic picture showed that the inflammation was characterized by the infiltration of mononuclear cells. In both diffuse and localized infiltration, the plasma cells predominated. In the case of the deciduous molar, there was acute inflammation, with polymorphonuclear leucocytes called in to fight the infection. The largest number of cases were caused by secondary caries under fillings. This etiological factor is often recognizable in the roentgen picture, especially when the cavity starts from the margin of the filling. In other cases, no defect could be seen under the filling, but still the microscope revealed infected dentinal canals.

These findings emphasize the importance of certain operative measures known to all dentists but, I fear, not always carefully observed. The sense of asepsis needs to be still further developed, and principles of sterilization must be carefully followed. The feeling that a tooth which has been cut into by a burr or other instrument, represents an open wound, must be acquired. A wound in a tooth should have the care and consideration that is given a wound on any other part of the body, perhaps more, because the injured dentinal canals represent a wound-surface more easily infected than a cut in the skin. A tooth does not have the facilities for protection that the soft tissues possess. The cleansing of a wound by hemorrhage from it, and the healing process which, in the soft tissues, includes the formation of a protective crust over the injured surface, are not present in dentine. It is no wonder, therefore, that a pulp becomes infected if a cavity, although properly prepared, is left unprotected for days until a jacket crown is set or an inlay is cemented into place.

No doubt some carious teeth have infected pulps when a patient presents for filling. But this condition should be discovered promptly, and not allowed to take its course until an acute abscess forms, or until the patient becomes a sufferer from neuralgic pains. The danger of general ill health through infectious absorption from a pulp abscess is very great. It is our duty to prevent it by making a careful diagnosis. I hope this contribution will be an aid in the recognition and elimination of pulp infections, and also, in their prevention.

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LYMPH CHANNELS IN DENTINE AND ENAMEL STAINED BY AMALGAM

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Although it is customary to study the various tissues of a tooth as distinct entities, nevertheless a broad view is obtained only after these separate ideas are correlated and synthesized and the tooth is regarded as a unit. The object of this paper is to present evidence for the conception of the tooth as a vital organ. The difficulty evidently centers around the notion of life and vitality. Perhaps, in passing, we may say that the vitality of a tissue is a matter of degree rather than definition, for the simplest life processes merge imperceptibly into purely physico-chemical phenomena.

It is necessary to bear certain facts in mind when thinking of a tooth. First, it is evident that, since the pulp is an end circulatory organ, it can be affected by vascular conditions throughout the body. And as the formative and nutritive organ of the dentine, it stands in vital relationship to the tooth.

Another essential matter is the work of Tomes (1). Waldeyer said that Tomes opened the way to a correct interpretation of the nature of the dentine, for he showed that each of the innumerable canals or tubules that permeate the dentine is occupied by a soft fibril, which is continuous with a cell upon the surface of the pulp. Tomes also discovered the granular layer of the dentine that underlies the cementum, and demonstrated the continuance of the dentinal tubules into these spaces. But Tomes did not believe that the enamel is permeated by organic fibers or tubes, and in 1894 wrote:

"Although there are various reasons for suspecting that enamel is not completely out of the pale of nutrition from the moment that a tooth is cut, yet further observations are needed before the activity and importance

of the cement substance demonstrated by Bödecker can be held to be fully established" (2).

C. F. W. Bödecker claimed that the living tissue of the pulp is in direct union with that of the dentine, cementum, and even the enamel (3). Certainly we have a broad biologic conception here. Of course it is absurd to suppose that there is a pulsating circulation of blood through any of the hard tissues of the tooth. Yet there probably is an actual circulation of lymph in the dentine by way of the soft fibers of Tomes and the dentinal tubules. And even in the enamel there is strong evidence of an organic or protein network surrounding the individual rods, which is capable of maintaining a greatly reduced lymphatic circulation or diffusion from the dentine.

Many able investigators have brought forth evidence confirming this view. The first problem was to ascertain whether enamel contained organic matter sufficient to carry fluids through this tissue; the second, to ascertain whether channels pass through the dentine across the dentino-enamel junction and into the enamel. These things have been done. The first problem was solved in 1905 by the celloidin decalcification method of C. F. Bödecker (4). By this method "as soon as the acid dissolves the lime salts of the enamel, the celloidin fills up the space and in this manner sustains the fine organic matrix." Sections of enamel showing this network were photographed under the microscope, so as to show definitely these delicate structures. Another pioneer in this work was Caush (5). He immersed teeth for several days in an alcoholic solution of fuchsin and then made ground sections of them. He reported that the stain permeated the protoplasmic fibrillae of the dentinal tubuli, and extended in fine lines into and even through the substance of the enamel.

Bunting and Rickert (6) were able to demonstrate the passage of sodium chloride and other salts from the pulp of a tooth through the dentine and enamel into the surrounding media, and conversely from the fluids outside of the enamel to the pulp. Their results were obtained by osmosis and diffusion. They concluded that, "if salt solutions will pass through the enamel and dentine of a tooth in the test tube, we may reasonably expect that in the mouth, owing to the salts of the blood on the inside and of those of the saliva on the outside there will be a similar osmotic flow."

Fish has also done very valuable work in this connection (7). He tried to ascertain "whether the dentine and enamel of a typical mammal (the dog), are irrigated by the body fluids, and, if so, to what extent and in what manner." The experiment was carried out as follows:

"India ink is gently instilled into the pulp of a live dog and left there for an hour. A larger young dog is selected in order to secure a larger pulp chamber and so relatively minimize the disturbance of introducing the hypodermic needle into it. The dog is anesthetized and an intravenous injection of chloralose is given. Part of the crown of a canine tooth is then sawed off to expose the pulp and a fine hypodermic needle is passed gently down between the pulp and the dentine to a point about half way along the root. A syringe containing Reeves waterproof india ink is attached to the needle, and as the needle is withdrawn, a trace of ink is allowed to flow without pressure into the space occupied by the needle. If pressure be used, the pulp will be dislodged and the lymph circulation will be interfered with. The ink may be left in either for one hour, to show the rapidity with which the particles are carried along the tubules, or for twenty-four hours to obtain a specimen showing somewhat deeper penetration of the ink and, at the same time, to allow the particles to enter a larger number of the tubules. In the latter case, chloroform is used without chloralose and a trace of arsenic may be placed on the exposed end of the pulp. Cement is then allowed to flow over the cut surface of the tooth to close the pulp chamber. After the time selected has elapsed, whether it be one hour or twenty-four, the dog is killed and the teeth that have been operated on are extracted, decalcified, sectioned, and mounted in balsam."

Fish summarizes the results of his experiments as follows:

"1. It has been demonstrated that the dentinal tubules are lymph channels through which a stream of lymph flows of sufficient volume to carry solid particles of pigment with it into the middle of the dentine.

"2. The flow takes place in these tubules in either direction, according to the varying pressure in the surrounding tissues.

"3. The terminal branches of the tubules anastomose to form a plexus at the periphery of the dentine. This marginal lymph plexus serves to complete the circuit of the lymph stream and carries lymph which has come to it from the pulp along one group of tubules, to some other part of the dentine, whence it may return to the pulp down the tubules in that region.

"4. A flow of body fluids has been observed to take place from the alveolar tissues across the cement into the dentine. The marginal lymph plexus becomes filled with these fluids, whence they find their way down the tubules to the pulp and out of the pulp chamber by the apical lymphatic vessels to the alveolar tissues once more. A direct lymph path from the alveolus to the pulp along the dentinal tubules has thus been demonstrated.

"5. The enamel has been shown to receive a considerable supply of lymph which penetrates it freely from the amelodentinal junction almost to the surface. The lymph supply is derived from the marginal lymph plexus of the dentin, whence tubules are seen to pass to the amelodentinal junction. At this point, these tubules give off fine branches to the individual enamel prisms.

"6. The lymph in the enamel is rigidly confined to the peripheral layer of the individual prisms. The body of the prism itself and the interprismatic substance appear to be quite free from lymph. It follows from this that the enamel prism has an organic cuticle or sheath, but that the rest of the enamel is relatively inorganic."

Another method of attack on this problem was pursued by Howe, who examined "tooth substance by means of spectrum analysis as offering a means for the possible detection of elements that might escape usual chemical investigation" (8).

"The first tooth examined was from a case of lead poisoning and was furnished by Dr. Aub, whose work on this subject is well known. Six spectra were photographed. These showed lines of calcium and magnesium. The magnesium line was heavy. The presence of lead in the tooth was clearly shown by a distinct lead line. There was also a faint mercury line. These substances were unquestionably contained in the lead which had poisoned the individual. The extreme sensitiveness of spectrum analysis may be seen in the fact that boron was found, indicating that the patient had used a mouth wash of boric acid."

Howe also presented photomicrographs showing a section of a tooth from a case of lead poisoning. The lead was clearly demonstrated in the interglobular spaces of the dentine and in the "tufts" of the enamel. "The deposition of lead in human teeth in cases of lead poisoning indicates that this substance was carried by the circulation. The fact that it remained signifies a union with the dental substance."

Amberson attempted to measure the electrical conductivity of the enamel, and inferred that it possesses a permeability of a low order (9).

"In all cases the membrane charge is probably due to the differential adsorption of positively or negatively charged ions on the surfaces of enamel including the walls of those minute channels which it would appear must be present in the structure in order to give the observed electromotive behavior. The profound modification of this behavior by various salt treatments indicates that a certain amount of the salt must permeate into the structure. Inasmuch as the electromotive determinations can be made, the electrical resistance of the enamel, though high, is not infinite and a certain amount of ionic movement through it must be inferred."

Beust, among others, has claimed for years that there is a circulation in the enamel (10). His method of demonstration was to introduce a dye into the apical canal of a tooth, by means of a syringe cemented into it, and to sustain the pressure for some time. He succeeded in driving the stain through the dentine and even the enamel. Others have repeated the experiment more or less successfully.

In contrast to these scientific demonstrations, the unique tolerance of dentine and enamel for all sorts of filling material has seemed to offer strong evidence for the absence of any "circulation" in these tissues. But there are certain changes that take place occasionally in dentine and even in enamel, after a tooth has been filled with amalgam, which can be explained by the theory of a circulation within the tooth. In 1881, Dr. Dwinelle said:

"I have made it a practice to particularly examine amalgam-treated teeth, and have often been surprised to find parts that were evidently once softened by decay had become fossilized as though the soft parts had absorbed a portion of the black metallic oxide thrown off from the mercury and silver so as to arrest decay, as though in fact, a kind of embalming process had transpired" (11).

Every clinician has probably seen teeth discolored by old amalgam fillings. The external surface of the filling is often blackened by sulphide in the saliva. And the inner surface of the amalgam is in all probability similarly affected by the lymph present in the dentinal tubules. Whatever happens to the alloy is a complex chemical problem, but it is certain, as the accompanying illustrations clearly

show, that some of the elements of the amalgam permeate the dentine by following the tubuli and also the organic sheaths surrounding the enamel rods.

It is difficult to say whether the black granules seen in the photomicrographs were transported from the filling along the tubules and the enamel-rod sheaths, or whether they were in solution and precipitated later. The black stain is certainly due to a very insoluble salt, for it remained even after some of the specimens had been decalcified in 5 per cent nitric acid. Incidentally, this shows how difficult it is to remove the stain under an old "silver filling" by chemical means. This insoluble black salt is probably mercuric sulphide formed by contact of the filling with sulphide in the dental lymph. The fact that this discoloration is not always seen in amalgam-treated teeth seems to indicate that it is due to the use of an excess of mercury in mixing the amalgam. Sulphur is present in the organic matter of the tooth itself as well as in substances in the lymph. When such an unsightly, discolored tooth is sectioned and examined under the microscope, a dark stained "reticulum" is seen in the dentine (*fig. 8*), for the stain has been carried along the dentinal tubules and their delicate lateral branches, thereby outlining the minute structure of a definite circulatory system. What is still more interesting is the fact that in certain small areas these granules of mercuric sulphide have been carried into the organic matrix of the enamel, and have deeply stained the delicate sheaths surrounding the individual enamel rods.

Fig. 1 is a photomicrograph of a molar which had been filled with amalgam. The filling itself usually falls out while such sections are ground to sufficient thinness for examination by transmitted light. This is a very low magnification (8 ×), intended to give a general idea of the distribution of the tissues and of the way the insoluble microscopic particles of the black stain have been carried into the tubules by the circulating lymph. At the right side of the photomicrograph, some of the salts have been carried across the dentino-enamel junction and have stained the enamel at *B*. *Fig. 2* is a little higher magnification of the same section. *Fig. 3* shows the dentino-enamel junction of the specimen seen in *fig. 1*, in the region marked *B*. This is a magnification of about 900×. The dentine is seen at *A*, and the microscopic granules of the black stain are distributed in the enamel at

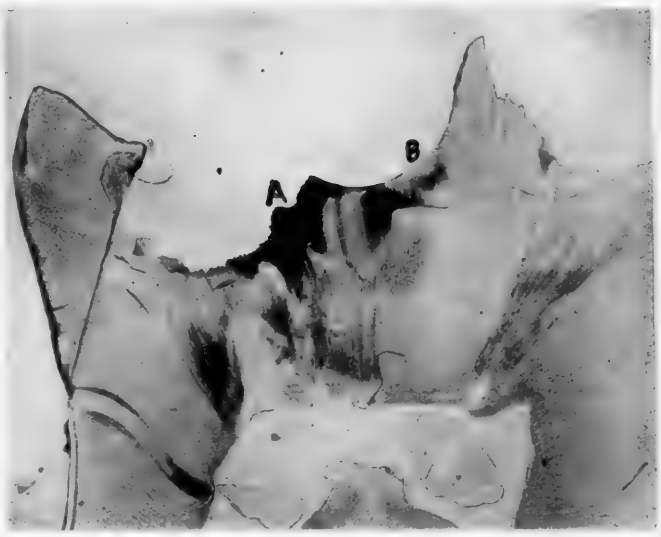

FIG. 1. PHOTOMICROGRAPH OF A MOLAR WHICH HAD BEEN FILLED WITH AMALGAM
A—Stained dentine. *B*—Stained enamel. Enlargement about 8×. (The filling was lost while grinding the specimen).

FIG. 2. SAME SPECIMEN AS *fig. 1*, UNDER SLIGHTLY HIGHER ENLARGEMENT (ABOUT 18×)

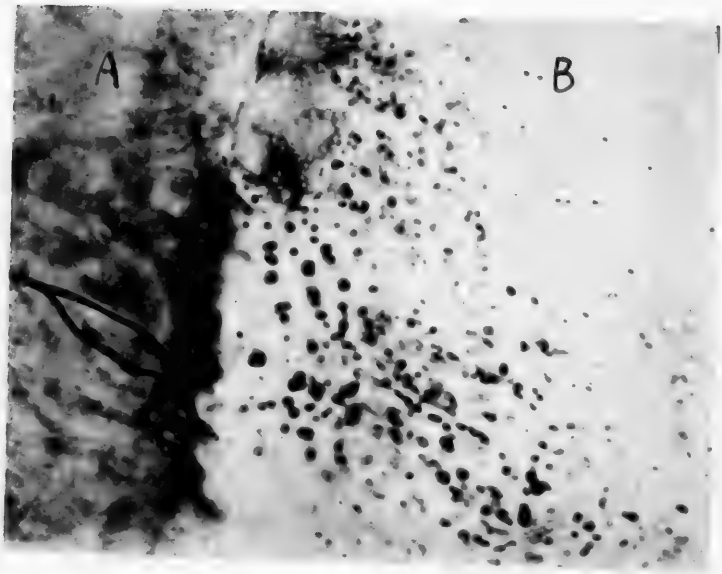

FIG. 3. DENTINO-ENAMEL JUNCTION OF *fig. 1*, UNDER HIGH ENLARGEMENT (ABOUT 900 ×)
Staining of dentinal tubules at *A*, and of enamel at *B*

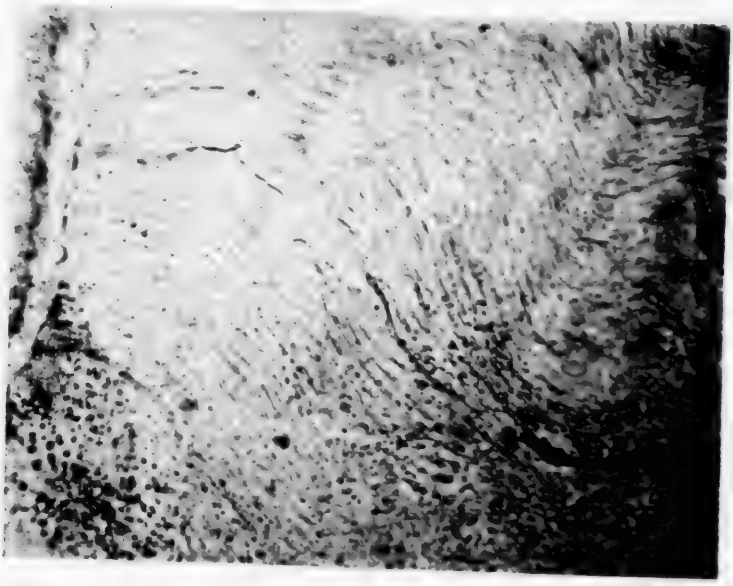

FIG. 4. ENAMEL-ROD SHEATHS IN LONGITUDINAL SECTION, STAINED BY GRANULES OF MERCURIC SULPHIDE. MAGNIFICATION: ABOUT 400 DIAMETERS

B. A similar picture is shown in *fig. 4* under a lower power (400×). This shows a larger area of the enamel, and it becomes evident that the granules of the stain are confined to the organic enamel-rod sheaths. *Fig. 5* is an enlargement of a part of the preceding figure, showing stained sheaths and disclosing their structural outline in longitudinal

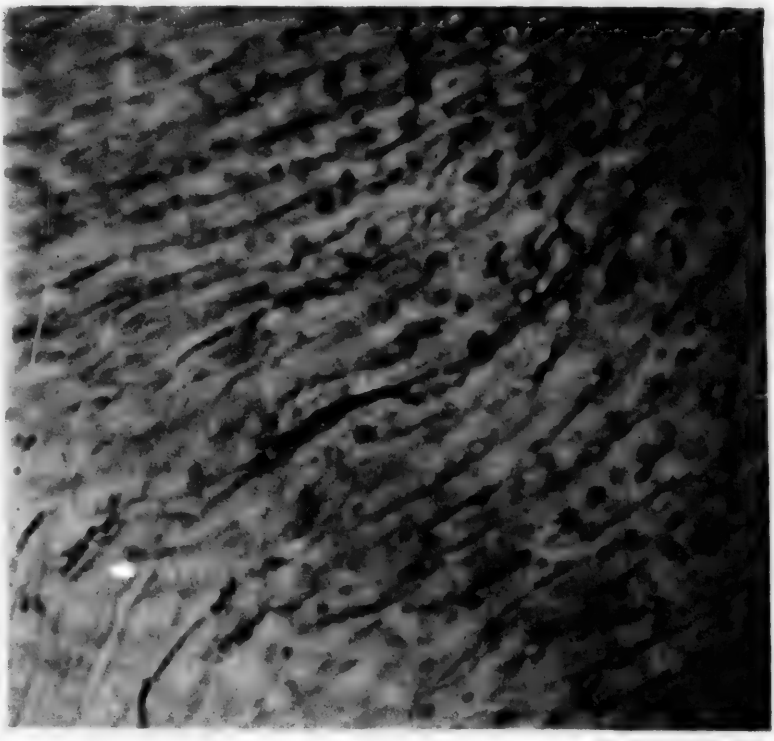

FIG. 5. ENLARGEMENT OF A PART OF *fig. 4*, SHOWING STAINED ENAMEL-ROD SHEATHS (ABOUT 1600×).

section. In *fig. 6*, the enamel-rod sheaths are seen in transverse section under a magnification of 2000 diameters. This photomicrograph was also taken from a part of the stained enamel in *fig. 1*. The granules show clearly in the sheaths around the enamel rods, although some seem to be in the rod itself. By a simple change of focus, how-

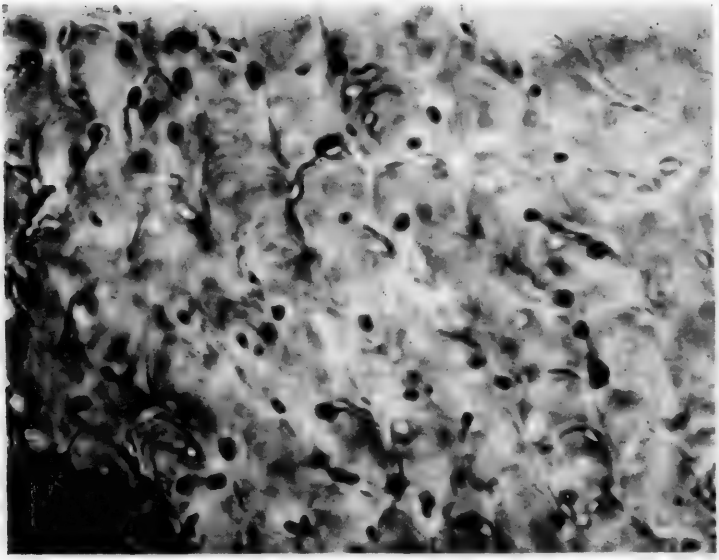

FIG. 6. ENAMEL-ROD SHEATHS IN CROSS SECTION, STAINED BY SALTS FROM THE FILLING MATERIAL. MAGNIFICATION: ABOUT 2000 DIAMETERS

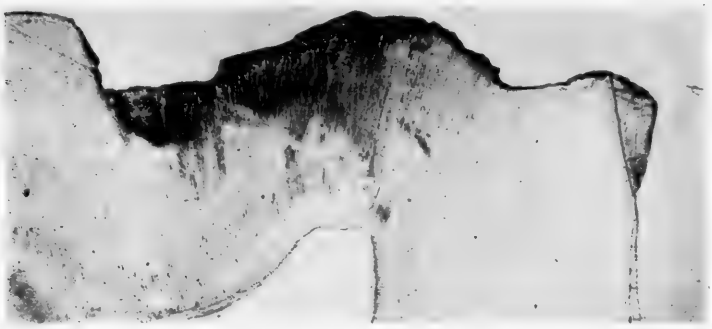

FIG. 7. PHOTOMICROGRAPH OF A MOLAR WHICH HAD BEEN FILLED WITH AMALGAM. The staining of the dentinal tubules is quite marked. Enlargement: about 27 diameters.

ever, it becomes evident that the granules are all confined to the organic sheaths around the rods.

Fig. 7 is a photomicrograph of another molar, which also had an amalgam filling in it. This is a low magnification, to show again the

FIG. 8. DENTINE OF *fig. 7*, UNDER A MAGNIFICATION OF ABOUT 2500 DIAMETERS

This shows the tubules and their lateral branches stained by salts from the filling material.

general distribution of the tissues, and of the staining due to the salts suspended in the circulating lymph in the tooth. One region of the stained dentine seen in the last figure is shown under an enlargement of

FIG. 9. DENTINO-ENAMEL JUNCTION OF *fig. 7*, UNDER AN ENLARGEMENT OF 670 DIAMETERS

This shows the diffusion of mercuric sulphide across the dentino-enamel junction, and the staining of an enamel lamella at *L*.

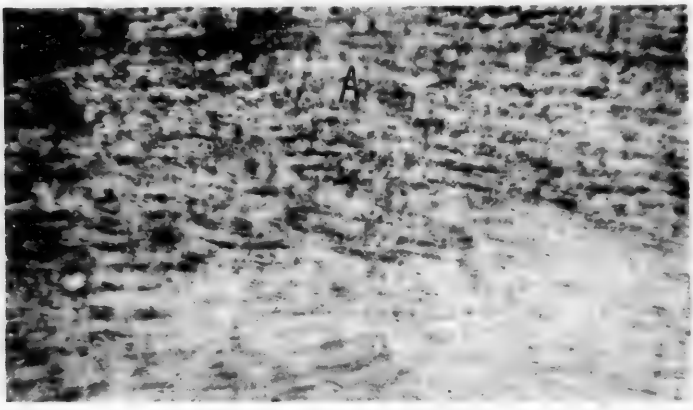

FIG. 10. ENAMEL OF *fig. 7*, UNDER MAGNIFICATION OF 670 DIAMETERS

This shows the enamel-rod sheaths in longitudinal section, deeply stained at *A* by salts from the filling material.

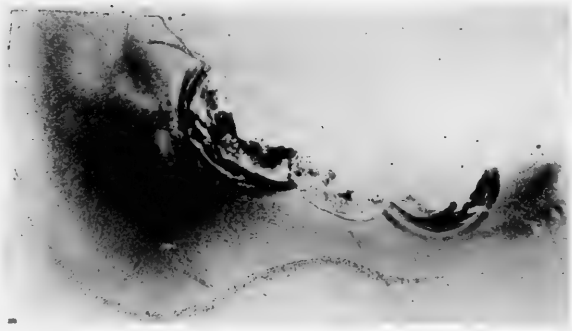

FIG. 11. DECALCIFIED TRANSVERSE SECTION OF HALF A MOLAR WHICH HAD BEEN FILLED WITH AMALGAM

Enlarged about 11 diameters. The black crescents are entirely due to the staining of the tooth by mercuric sulphide.

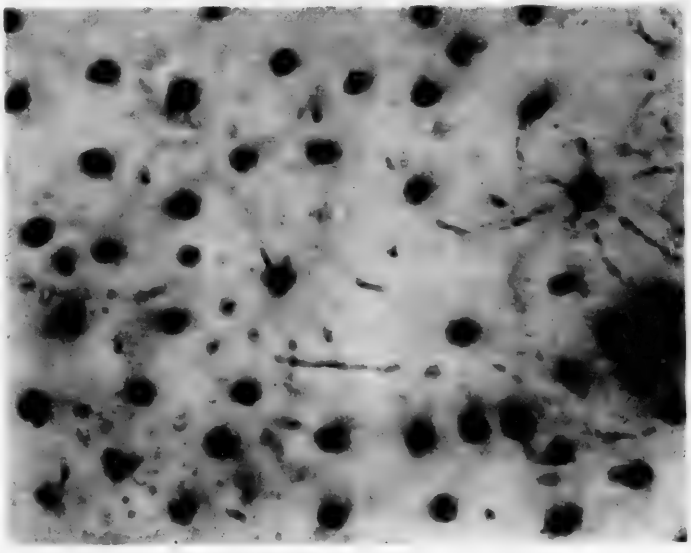

FIG. 12. DENTINAL TUBULES IN CROSS SECTION, FROM A STAINED CRESCENT IN *fig. 11*, SHOWING GRANULES OF MERCURIC SULPHIDE IN THE PERIPHERY OF THE TUBULES. ENLARGEMENT: ABOUT 2000 DIAMETERS

2500 diameters in *fig. 8*. This photomicrograph shows the "reticulum" of the older histologists. The network formed by the dentinal tubules and their lateral branches is very deeply stained by the salts from the filling material. *Fig. 9* shows the dentino-enamel junction of *fig. 7*. *L* is an enamel lamella that has been stained by the diffusion of the

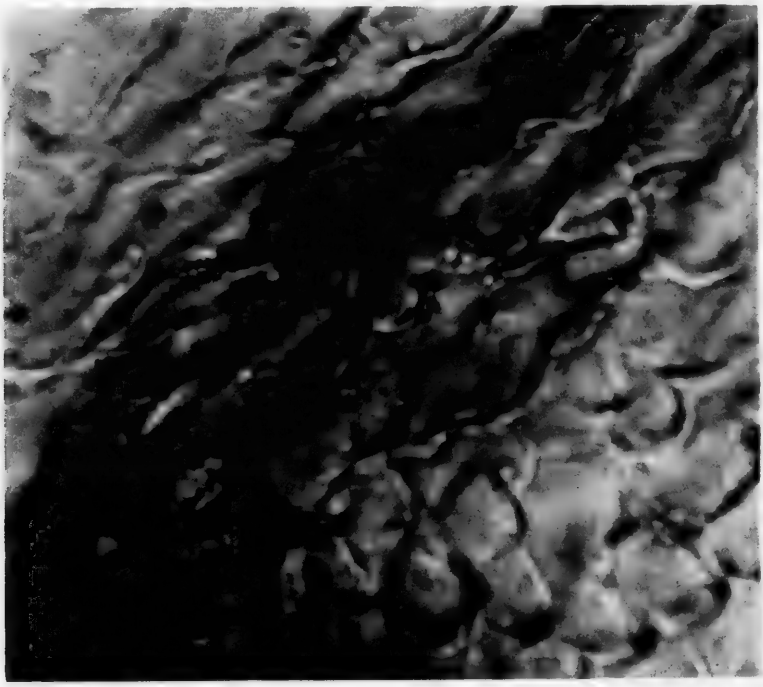

FIG. 13. ENAMEL-ROD SHEATHS OF *fig. 11*, UNDER A MAGNIFICATION OF 2700 DIAMETERS.

This shows the organic matrix of the enamel, and the black stain which persists even after decalcification.

black salt across the dentino-enamel junction. *Fig. 10* is taken from stained enamel in this region, and shows the enamel-rod sheaths in longitudinal section deeply stained by the mercuric sulphide.

The preceding figures have been taken from ground sections, but *fig. 11* is a photomicrograph of a decalcified specimen. The filling was drilled out before decalcifying the tooth. *Fig. 11* shows a cross-

section of this decalcified specimen. The two black crescents are due to the staining of the tooth by the filling material. The specimen was not stained with a histologic dye. The two black crescents seem to show a limitation of the lateral diffusion of the mercury salts. A similar zoning is often seen in cross sections of decayed teeth, and may be an attempt on the part of the dentine to resist the lateral spreading of the disease. When the black crescent of dentine seen in *fig. 11* is placed under a higher magnification, as in *fig. 12*, it becomes evident that the stain is due to a heavy deposit of mercuric sulphide outlining the circumference of each tubule and extending into the lateral branches. It is interesting to note that the stain is confined to the periphery of the dentinal tubule, that is, the space around the fiber of Tomes.

A rather novel feature of this decalcified specimen, seen in *fig. 11*, is the retention of a little island of organic matrix of the enamel between the two black crescents. The organic network has been retained even after the inorganic salts have been dissolved by the nitric acid. This is unusual for, as is well known, the enamel is usually entirely lost when a tooth is decalcified in an aqueous solution of an acid. The organic matrix of enamel is only retained by the celloidin decalcifying method. When this island of enamel is placed under a high power (2700×), as in *fig. 13*, the organic enamel-rod sheaths are seen clearly outlined by the granules of the black salt.

In conclusion it must be granted that there is a great difference between the simple diffusion occurring in the hard tissues of a tooth and the complex metabolism in some of the cellular tissues of the body. But this is the inevitable result of the unique specialization of the teeth in form and function. Enamel, which is as dense as the mineral apatite, does not need a complicated metabolism to perform its purely mechanical function. But it differs from apatite in retaining an organic matrix—the mark of its origin. And this organic matrix makes it possible for this dense "coat of mail" to possess some "vital" relation to the body fluids throughout life.

It gives me great pleasure to acknowledge my indebtedness to Dr. Charles F. Bödecker for his guidance throughout this research.

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A CASE OF HETEROTOPIC OSSIFICATION IN AN UNTREATED GRANULOMA

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The specimen was an old, lower, molar root that had remained untreated and neglected in the jaw for years. The patient from whom it was removed was 72 years old. There was some resorption of the tissues about it, and it was fairly loose. When extracted, a medium sized granuloma was found adherent. This was prepared for histological examination, because it is my practice to prepare all tissue as a matter of routine. The specimen was fixed in 10 per cent formalin, and then decalcified in 5 per cent nitric acid; washed for 24 hours in running water; dehydrated in ascending alcohols through absolute alcohol and ether; and passed through ascending percentages of celloidin, in which it was finally embedded. Sections were cut and stained with haematoxylin and eosin.

Where we expected the usual picture of the granuloma, with its round-cell infiltration, fibrous capsule, and occasional epithelial cells, we found mostly fibrous tissue, with scarcely any round cells, and a small island of bone actively forming in almost the center of the granuloma.

Fig. 1 is a low-power photomicrograph of the specimen. At *A* is the root cementum, which appears regular and even. The entire field is composed of fibrous connective tissue, with little evidence of round-cell infiltration. At *B* is the island of ossification. *Fig. 2* is a higher enlargement of *B*. About the border of the ossified mass are osteoblasts staining sharply, and evidently vital and active.

This is a case of bone metaplasia, or heterotopic ossification. In the course of a great many histological examinations of this lesion, this is the first time I have found bone forming in a granuloma, and it is sufficiently rare to be reported. Why it is not found more often is difficult to understand, because, from a study of the various theories of heterotopic ossification and especially that of Leriche and Policard, the granuloma should be a fertile field for the growth of bone. It

might be well to take up briefly some of the views as to the genesis of this phenomenon.

Bone is a derivative of connective tissue. Dissolve the calcium salts out of bone, and there remains the fibrous collagenous base.

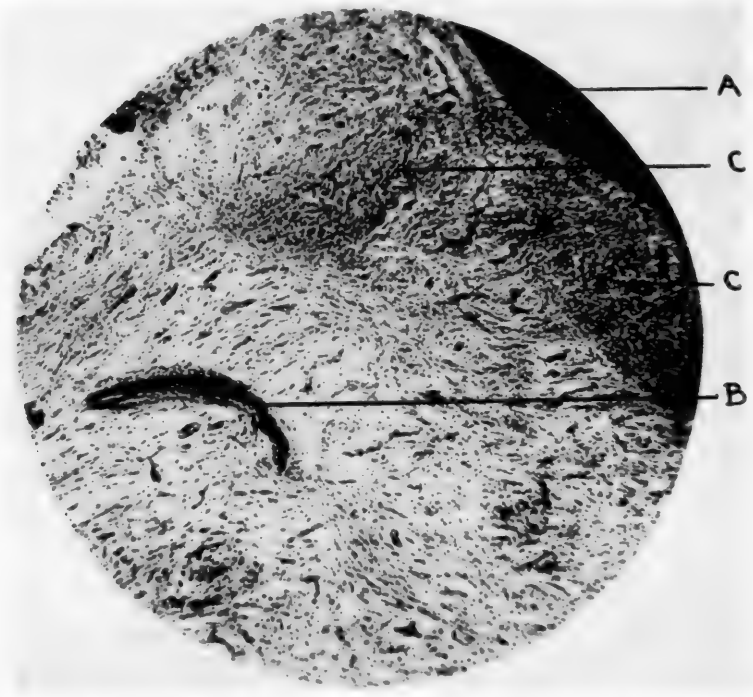

Fig. 1. A low-power photomicrograph of a section of the granuloma adherent to the root. *A*—Root cementum. *B*—Island of ossification. Note that the field is composed chiefly of fibrous connective tissue, with scarcely any evidence of inflammatory infiltration. At *C* are fibroblasts cut transversely, which makes them look like round cells. To allay all suspicion that this bone might be an adherent spicule of alveolar process, serial sections were made. The first sections showed no bone at all. Then a small area was observed, which grew larger in subsequent sections, until a maximum was reached. The bone island then diminished in size and finally disappeared, and the last sections again showed no bone.

Likewise fibrous connective tissue can be transformed into bone through metaplasia. According to Leriche and Policard, in order to have bone formation, there must be an ossifiable medium and a

source of calcium. Owing to some change in the cells, which may be brought about by mild infections, altered metabolism, or diet, the connective tissue reverts to an embryonic state. This is the "ossifiable medium," which Leriche and Policard say simply "means that histological modification renders the connective tissue liable to impregnation."

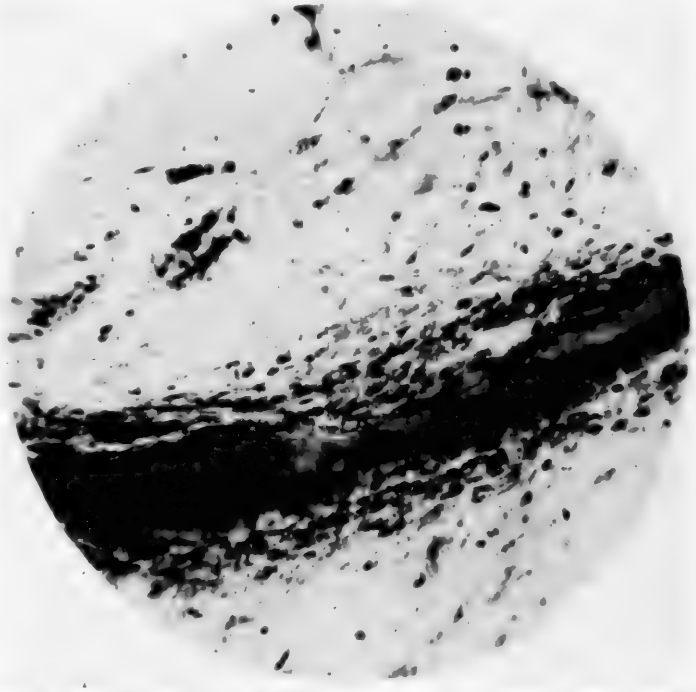

Fig. 2. A higher enlargement of the island of ossification. Note the sharply staining osteoblasts along its borders.

The immediate source of calcium is still unknown. Necrotic tissues at times calcify through precipitation, and tissue in which the circulation is sluggish or retarded exhibits the same phenomenon. However in these cases the hardened part does not histologically resemble bone. But where true bone does form in a tissue not normally possessing it, a condition called "heterotopic ossification" occurs, the reason for which is still more or less of a mystery.

It is generally believed that the osteoblast is a connective-tissue cell that has the power of secreting calcium salts or rather bone-forming salts. On the basis of this theory, Macewen explains heterotopic ossification by saying that osteoblasts migrate through the blood like leucocytes, and lodge in some tissue especially prepared by the changes mentioned above to receive it, thus starting bone formation. Cohnheim explained all heterotopic ossification by claiming that it arises from a misplaced spicule or focus of embryonic bone. This theory is analogous to his embryonal-rest theory as the cause of cancer. Lastly, Leriche and Policard state that heterotopic ossification is produced only in a connective-tissue medium in the "vicinity of a calcified deposit or of a point of phosphocalcific concentration." The calcium salts are removed from their source through resorption, and fixed by the specially prepared tissues. How this is done is not clear. Possibly the osteoblast has the power of selecting calcium salts from their source and fixing them, instead of secreting these salts.

In the present case, the granuloma is composed of fibrous connective tissue, a part of which through some unexplained cause has reverted to an embryonal stage, and thus has become an ossifiable medium. There is plenty of calcium storage in the vicinity: in the root itself, or in the neighboring trabeculae of the alveolar process. Calcium is resorbed from one of these sources; and osteoblasts, which are fibroblasts with a special function, fix these salts in the "ossifiable medium," thus forming bone.

The finding of bone in this specimen shows the possibility of ossification of granulomas as a method of healing. The inflamed and infiltrated mass may be transformed, through treatment of its cause and sterilization, into connective tissue, which in turn may revert to embryonic tissue and become ossifiable. With the tremendous amount of calcium in the neighborhood, osteoblasts may be induced to form bone.

SUMMARY

A case is presented of an old untreated root with a granuloma adherent, which on section showed heterotopic ossification.

Various theories are given as to the formation of heterotopic ossification.

The possibility of inducing this condition as a method of healing granulomas is suggested.

865 West End Avenue,
New York City

A STUDY OF THE EFFICIENCY OF DENTAL FILLINGS[1]

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I. INTRODUCTION

Since the days of Black and Wedlestedt the only extensive studies of the efficiency of dental fillings have been those undertaken by certain commercial firms. The object of these firms has been the improvement of the quality of their products, but it is quite natural that manufacturers should take interest chiefly in types of research that would furnish attractive advertising material. The present research was undertaken in order to determine (a) if certain of the dental cements and fillings on the market were germicidal; and (b) if any of these cements or fillings would permit bacteria to pass through or around them.

Nine types of fillings and cements were used:

(1) Copper cements, five varieties
(2) Copper amalgam, one variety
(3) Oxychloride of zinc, one variety
(4) Temporary cements, two varieties
(5) Alloys, four varieties
(6) Gutta-percha stopping, one variety

[1] Read at a session of the Third Annual Meeting of the International Association for Dental Research, Congress Hotel, Chicago, Ill., March 20, 1925; *Journal of Dental Research*, 1928, viii, p. 219.

(7) Gutta-percha, three varieties
(8) Silver cements, two varieties
(9) Silicate cements, two varieties

The particular ones of the above types that were chosen to represent a group were selected either because of their popularity, because of the rather extreme claims of the makers, or because we believed them to have some special claim or value.

II. GERMICIDAL POWER OF CEMENTS

Not all of these cements and fillings are, of course, expected to be germicidal, and the manufacturers put forth no such claims for them. But some, especially the copper and silver cements, are widely advertised and believed to have germicidal properties. These were of the greatest interest, but all of the others, except the silicate cements, were tested as controls.

A. Method and results

The method employed was as follows: The cements and fillings were mixed according to the given directions and moulded in a vise into cubes of 4 cmm. size. When quite set, some were kept in sterile distilled water several days before testing; others were not. Pour-plate cultures were made, using 0.5 cc. of a 18-hour broth culture and 10 cc. of agar agar for each plate. In the earlier tests, cultures of Bacillus coli were used; later, Bacillus proteus, as it renders the medium alkaline and not acid when growing. Three cubes of one kind of cement or filling were placed on a plate before it hardened. On incubation, the plate became uniformly opaque except in the areas in which the growth of bacteria had been inhibited. In these areas, about the cubes of cement, the agar remained clear. The diameter of the area of inhibition was measured with a millimeter scale. For comparative purposes, it was considered that the amount of soluble germicide in the cement, and its ability to diffuse into the agar, was in proportion to the diameter. Measurements were made after 48 hours' incubation and after seven days. About every eighth day the pieces of cement were put on new plates. This was continued until no inhibition was obtained on at least two successive transfers.

When the cubes, without soaking in water, were plated immediately

after being removed from the moulds, varying degrees of inhibition were obtained, ranging from a diameter of 7 mm. to 22 mm. The gutta-percha and gutta-percha stopping showed none whatever. The second time the cubes were plated there was a marked decrease, some of the fillings showing no inhibition of growth. With the copper-amalgam cubes the inhibition area was increased. In all but two fillings—a silver cement and copper amalgam—there was a complete loss of apparent germicidal power after five transfers. Two of the copper cements retained the inhibitory effects for five transfers, but the others lost practically all in the second or third plating. The time factor in the loss of germicidal power, after the first plating, was not as important as the number of platings, the second plating giving about the same area of inhibition whether 7 days or 14 days had elapsed between platings.

The cubes that had been kept in sterile water, or even exposed to the air a number of days before plating, showed an area of inhibition on the first plate about equal to that obtained on the second transfer of those in the tests described in the preceding paragraph. For example, one copper cement, plated eight hours after moulding, showed areas of inhibition with diameters of 17 mm. and 20 mm. The same mix of cement, in water for five days before plating, gave inhibition areas 6 mm. to 8 mm. in diameter. The first germicidal power of the cements is obviously due to the free acid used in mixing the cements. This free acid is evaporated, or reduced in amount as a result of further reactions, by letting the cubes stand, or washed out by putting them in water or by the successive transfers. In filling a tooth this germicidal effect must be considered an important factor, especially if the cavity has been imperfectly sterilized. However, if infection enters the cavity after it has been filled, the cements or fillings cannot be expected to exert any germicidal effect.

The two exceptions referred to above were a silver cement and copper amalgam. This silver cement in one trial retained some of its germicidal power for fourteen transfers. In other tests, the same cement lost it more rapidly. The initial diameter of the area of inhibition was no greater than that of some of the others, which lost all inhibitory power immediately. The increase in the time required to lose its germicidal power was, therefore, owing not to the greater

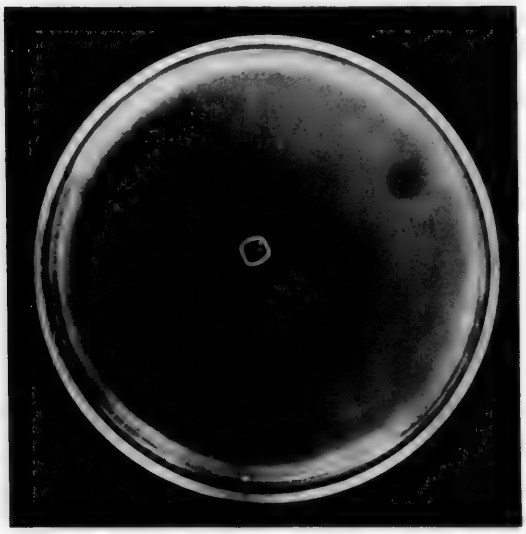

FIG. 1. SHOWS AREA OF INHIBITION OF GROWTH OF BACILLUS PROTEUS AROUND A CUBE OF GERMICIDAL CEMENT

FIG. 2. SHOWS NO AREA OF INHIBITION ABOUT A CUBE OF NON-GERMICIDAL CEMENT

amount of free acid to be removed but to some soluble factor in the cement. (See *figs. 1* and *2*.)

B. Copper amalgam

The copper amalgam was of particular interest. After the first transfer the diameter of the area of inhibition increased from 7 mm. to 22 mm. on the fourth transfer. This then decreased to about 10 mm. on the tenth transfer, and remained about this width for over fifty transfers. The whole plate on incubation became more or less green, and the growth was not as dense as that on the plates with other fillings made at the same time. The copper obviously was soluble and responsible for the germicidal effect. The total weight of four cubes of copper amalgam, when made, was 3.2012 grams. After five transfers, extending over three months, they weighed 3.0150 grams, a loss of 5.8 per cent. Three cubes, when first made in March, 1920, weighed 2.6232 grams. After being plated more than fifty times during two and a half years, they weighed 1.2860 grams, a loss of about 49 per cent.

It was thought that perhaps CO_2 of the air, acid in the media, or bacteria, or all of them, were responsible for the disintegration of the copper. Therefore tests were made as follows: (a) Into two tubes of agar, plus 0.5 acid to phenolphthalein, cubes of amalgam were placed. One was inoculated with Bacillus proteus, the other was not. (b) Another set was prepared as above, but the agar was neutral to phenolphthalein. (c) Four cubes were plated as usual on pour-plates in which the acidity was plus 0.5 to phenolphthalein. These were all done in duplicate, one series having been incubated at 37°C., the other at room temperature (17°–21°C.).

All the tubes and plates, on standing, showed some green color in two weeks, the least being in the acid tube inoculated with Bacillus proteus that had been kept at room temperature. The tubes and plates in the incubator, as might reasonably be expected, became green a little sooner than the others, but there was very little difference between any of the tubes. The plates appeared green sooner than the tubes, but the difference was not so marked that it could not be attributed to better conditions of observation, as the agar was in a thinner layer on the plate and did not mask the green color. The

solubility of the copper did not appear to be affected either by the reaction of the media or by the bacteria.

In considering the germicidal power and the solubility of the copper, it must be remembered that in these tests five sides of the cubes on

FIG. 3. AMPULES, WITH THE TOPS FILLED WITH CEMENT
Some are immersed in a broth culture

the plates, and six sides of those in the tubes, were exposed to the solvent action of the medium; whereas in a dental filling two sides at most, and more often but one side (as copper amalgam is generally used in box or four-wall cavities) would be exposed to any such solvent

action. Therefore the germicidal effect would be present on the exposed surfaces, but the disintegration of the copper amalgam per gram-weight would be much less.

C. Conclusions

(1) All the cements, when first mixed and plated as soon as hard, are germicidal owing to the excess of acid used in mixing the cements.

(2) All the cements and fillings tried by this technique, with one exception, lost all germicidal power after repeated transfers. One silver cement retained its inhibitory power much longer than any of the others.

(3) Copper amalgam is markedly germicidal owing to the solubility of the copper. It might be used with decided advantage, where the discoloration of the tooth is not a factor that need be considered, as a temporary filling, in root canals, in cavities below the gingival line, and when it could be covered on the exposed surface by capping or another filling.

III. PERMEABILITY OF DENTAL CEMENTS

A. Method and results

To test whether the above cements would permit bacteria to pass through, or around them, the following technique was used: Small glass ampules, about 5 cm. long and made of glass tubing 6 mm. in diameter, were constricted to 1 mm. to 2 mm. about 5 mm. from the open end (*fig. 3*). This made a cavity to represent the tooth cavity and the constricted part corresponded to the root canal. The inside of the cavity was etched with hydrofluoric acid in order to give the fillings a rough surface to which to adhere, thus more closely resembling the conditions found in a tooth cavity. The lower part of the tube was filled with plain broth (7.2 pH) and sterilized. The cements were mixed according to the given directions, on a sterile plate and with sterile instruments, and the open tops of the ampules were filled. At least twelve ampules were filled with each cement; in some cases, many more. After the fillings had set, the ampules were washed several times in sterile distilled water, then in alcohol, and immersed in flasks containing sufficient sterile broth to cover them completely.

After two days' incubation any ampule within which the broth appeared cloudy, indicating contamination, was discarded. This occurred very seldom.

The broth in the flasks was then seeded with Bacillus proteus. In a few of the first tests Streptococcus viridans and Bacillus coli were

TABLE 1

*Permeability of cements and fillings to bacterial cultures**

FILLINGS	AVERAGE NUMBER OF DAYS IN CULTURE	NUMBER OF AMPULES	PERCENTAGE STERILE
Copper cements: 1—black	269	20	100
2—black	370	12	100
3—red	95	18	100
4—white	245	13	92
5—white	259	25	92
Copper amalgam	158	19	100
Oxychloride of zinc	340	24	100
Temporary cements: 1	49	15	100
2	272	18	100
Silver cements: 1	225	37	68
2	247	36	67
Silicate fillings: 1	85	13	100
2	85	14	100
Alloys: 1	135	12	100
2	135	12	100
3	135	14	100
4	135	12	100
Gutta-percha stopping	120	24	37
Gutta-percha: 1	135	13	100
2	135	13	100
3	135	12	100

* All the ampules of one filling were not prepared at the same time; various mixes are therefore represented. Also, some were exposed for longer periods than others—none for less than 45 days; most of them for a longer time. Averages are given in the tables. This comment applies also to the data in *Table 2*.

used. Both Bacillus proteus and Bacillus coli are small, motile organisms, which grow very readily in plain media, and were therefore most suitable, Bacillus proteus especially so, as it does not produce acid. The motility is probably of no importance, but it was thought that, as a cement which remained impermeable to motile organisms undoubtedly would be impermeable to non-motile ones, it would be

preferable to use motile forms. The ampules were examined from day to day and any that appeared opaque were removed and opened. Smears were then made to determine if the organism within the small ampule was the same kind as that in the surrounding medium. If the

TABLE 2

*Permeability of fillings to water**

FILLINGS	NUMBER OF AMPULES	NUMBER OF DAYS IN WATER	RESULTS
Copper cements: 1—black	14	46	No water
2—black	15	146	No water
3—red	11	200	No water
4—white	13	46	Some doubtful
5—white	25	81	One definitely with water; others suspicious
Copper amalgam	19	103	Three with water
Oxychloride of zinc	24	100	One definitely, several doubtful
Temporary cement: 2	18	125	Water in two
Silver cements: 1	31	112	Seven definitely, with water
2	26	145	One mix of thirteen was very permeable, others were not
Silicate fillings: 1	13	150	All doubtful
2	14	150	No water
Alloys: 1	12	110	No water
2	12	110	No water
3	14	110	No water
4	12	110	Doubtful
Gutta-percha stopping			
Gutta-percha: 1	13	110	Six doubtful
2	13	135	No water
3	12	110	Water in seven

* See the footnote under *Table 1*.

organism was the same, it was considered to have passed either through or around the filling—either being unsatisfactory, from a dental point of view, for a dental filling. After the ampules had been exposed to broth cultures for varying lengths of time, ranging from 50 days

to 412 days, they were placed into sterile distilled water for about six weeks, as it was thought that the cements might be impermeable to broth cultures but permeable to water. If they were impermeable to water, they would probably be impermeable to broth and saliva. This was found to be the case, for none except gutta-percha, which will be discussed later, showed any growth within the ampule when put into broth cultures after being in water.

Table 1 gives some of the results from exposing the ampules to bacterial cultures. From the data in this table it may be seen that all the black and red copper cements, and the alloys, were quite impermeable to the bacteria. The white copper cements appeared less efficient. The copper amalgam also appeared to be almost invariably impermeable, but it is a question whether these negative results were due to its impermeability, or to the direct germicidal action of the copper before the bacteria could arrive in the ampule. This may also be a factor with the black copper cements for, although on the plates of the germicidal tests no green color could be seen, yet the broth within the ampules, after several months, became obviously green, indicating that some of the copper was soluble. This was even more marked in the flasks when the broth on the ampules was not poured off, but just replenished as it evaporated.

Contrary to expectation the oxychloride of zinc, temporary cements, and synthetic porcelains remained 100 per cent sterile. A considerable difference was found between gutta-percha stopping and gutta-percha. The stopping was quite unsatisfactory, but gutta-percha—three varieties exposed for 45 days at 37.5°C. to bacterial culture—remained 100 per cent sterile. Each was then exposed to water for 120 days and remained impermeable. They were again exposed in a broth culture at room temperature (20°C.); in twenty days, growth was shown by 3 out of 14 of one variety; by 2 out of 12 of another. Change of temperature, thereby causing contraction, was probably the factor responsible, the bacteria thus being enabled to pass between the filling and the wall. In using gutta-percha as little heat as possible should be employed.

The two silver cements were the most unsatisfactory. Great variation was found between different mixes of each. One series of 19 ampules exposed about 100 days remained 84.5 per cent sterile. This

irregularity of results with the two silver cements was found repeatedly. It would therefore appear that under perfect conditions they may be quite impermeable, but require more careful technique in mixing and filling to obtain the best results.

Table 2 shows some of the results when the ampules were placed in sterile water. Exposing the cements to water is, of course, quite unfair to them, for the conditions in the broth more closely resemble the conditions in the mouth. Water might pass through or around the fillings, whereas the more vicid saliva would not do so. This is probably the reason why so many, which had withstood the bacteria culture, permitted water to pass within. Silver cement 2, which admitted bacteria in so many tests, is of particular interest, for none of the ampules that withstood the bacterial cultures permitted the water to pass within. This is confirmation of the idea that these cements are subject to great error in the technique of mixing and filling. The cements that withstood the water should of course be considered most efficient, but the conditions are rather extreme.

B. Conclusions[2]

(1) The black and red copper cements were most efficient, the white ones less so.

(2) Copper amalgam is sufficiently impermeable or germicidal to be a most efficient filling, especially if it is protected on the oral surface in some way. No doubt if left exposed for a long time it would become permeable, as the copper would disintegrate.

(3) The silicate cements were impermeable to bacteria, but one kind was not impermeable to water.

(4) Gutta-percha stopping is most inefficient to seal a cavity, but gutta-percha, if properly put in, should be quite satisfactory.

(5) The silver cements require more careful technique in mixing and filling.

[2] See also the conclusions on page 513.

THE GERMICIDAL EFFECTS OF THE ULTRA-VIOLET RAYS ON STAPHYLOCOCCUS AUREUS

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I. INTRODUCTION

Although many clinicians claim to have had beneficial results with the therapeutic application of ultra-violet rays in dental disturbances, as yet comparatively little has been done experimentally to substantiate these results, and thus their application in the main has been empirical. In fact, the action of the ultra-violet rays as well as their penetration are still open to discussion. The present investigation was instituted with the hope of acquiring further knowledge of the ultra-violet part of the spectrum, as regards its germicidal power, and thus its therapeutic value.

The therapeutic application of the ultra-violet rays has led to the production of numerous lamps. These consist mainly of two types: (a) carbon arcs, (b) quartz mercury vapor lamps. These two types have been compared, and the investigations, notably Bleibaum's (1), have shown that the mercury lamps emitted more of the shorter rays as far down as 200 u.u., whereas the carbon arcs gave out more of the longer rays from 230 u.u. up. Different carbons emit rays of different

wave-lengths. A study of the germicidal power of the rays, as given out by different carbons, therefore not only would reveal the bactericidal range of the ultra-violet part of the spectrum, but also, in their therapeutic application, would be of great value to the clinician.

II. EXPERIMENTS ON CARBONS

Our experiments consisted of exposing a surface culture of Staphylococcus aureus to the rays emitted by the Brite-Sun Lamp, operating on alternating current with the National Therapeutic Carbons, A, B, C, D, E, F, G, H, and K, respectively, as electrodes. The lamp was

TABLE 1

The germicidal efficiency of the National Therapeutic Carbons, with reference to Staphylococcus aureus

CARBONS	BEGINNING OF INHIBITION	LETHAL EXPOSURE
	seconds	*minutes*
C	15	4
A	120	
B	30	
D	60	Some colonies were still present, with all other carbons, after 15 minutes exposure
E	60	
F	45	
G	75	
H	90	
K	15	

adjusted to have the angle of emission about 45° to the surface of the culture, the distance between the surface of the agar medium and the arc being 315 mm.

Petri dishes with a nutrient agar base were superficially inoculated with four drops from a sterile graduated pipette containing a 24 hour pure culture of Staphylococcus aureus. This contamination was next spread evenly over the surface of the agar by means of a platinum wire, and the petri dishes were placed in an incubator at 37°C. The current was next switched on, the stop clock set for the required time, and a petri dish removed from the incubator, opened, and the surface contamination exposed to the rays emitted by the various carbons, for the same length of exposure. Following this, the petri dish was returned to the incubator and examined the next day. This pro-

cedure was repeated, increasing or diminishing the time of exposure, with the object of determining (a) at what exposure time the first signs of inhibition begin, and (b) what exposure is required to produce total destruction.

Cultures were made by scraping the irradiated areas of all petri dishes with a platinum loop. Cultures made from the non-irradiated field of all dishes showed growth. On examining the petri dishes with an ordinary microscope under oil immersion, it was observed that the irradiated field of all dishes, except that irradiated with Carbon C for 4 minutes, contained plaques of cocci between and about the separate colonies which could be seen with the naked eye. (*Table 1.*) Two cultures were made from scrapings of these plaques, by means of a platinum loop, as follows: (a) From scrapings between the colonies, made by aid of the naked eye; (b) from scrapings with a loop, under a special binocular microscope, which showed the colonies very clearly, but not the plaques. Both cultures gave negative results. The plaques evidently were only the remains of some of the cocci, which had already been destroyed.

Our findings seem, therefore, to substantiate the observations of Victor Henri (2), who states that when the organisms are small the entire protoplasm is affected, and the action obeys the law of simple photo-chemical reaction. If they are large, the effect is a surface one owing to the small penetration of the ultra-violet rays. In the latter case the protoplasm affected may, by a process of diffusion, influence the rest, and the process is similar to a complex photo-chemical reaction on a strongly absorbing surface.

In the first experiments with Carbon C, a cotton applicator was used for contaminating the petri dishes, with the result that even after 15 minutes exposure, some colonies were still present in the irradiated area. Upon examining these colonies with a binocular dissecting microscope, a fine thread of cotton fiber was seen to pass through each colony. It seemed that this fine piece of cotton fiber was sufficient to protect some of the cocci, which thus survived the irradiation. Following this discovery the regular routine of contamination was changed to that outlined above, with the result that irradiation with Carbon C for 4 minutes was repeatedly found to be lethal.

III. GERMICIDAL EFFICIENCY AND QUANTITY OF SHORT RAYS

It is interesting to compare our findings with those of Goodman and Anderson, who undertook a quantitative analysis of the rays emitted by the various National Therapeutic Carbons, as well as the quartz mercury vapor lamp. Such a comparison is given in *Table 2*, which shows the amount of ultra-violet rays of wave-lengths less than 290 u.u., given out by the various carbons as cited by Goodman and Anderson (3), and the inhibition time as found in our experiments.

TABLE 2

The relationship between the inhibition time and the quantity of short rays given out by the different carbons

CARBONS	UNITS BELOW 290 U.U.[1]	INHIBITION TIME
		seconds
A	0.407	120
B	1.441	30
C	3.197	15
E	0.577	60
F	1.228	45
G	0.668	75
H	0.439	90
K	0.763	15

[1] Ultra-violet units in ergs per second, per square mm. of area at forty inches, for wave-lengths of 290 u.u. and shorter, down to 245 u.u.

Carbon C. According to the results outlined in *Table 2*, it is evident that Carbon C has greater germicidal effects on Staphylococcus aureus than any of the other carbons used, lethal effect being produced in four minutes exposure, and inhibition beginning in 15 seconds. This carbon contains nickel, iron, and aluminum, and emits a spectrum that is comparatively rich in the middle ultra-violet. Of all the carbons used in the present study, Carbon C, according to Goodman and Anderson, gives off the greatest quantity of rays below 290 u.u., namely 3.197 units.

IV. INHIBITION TIME AND QUANTITY OF SHORT RAYS

If the inhibition time of the other carbons be compared with the quantity of short rays given off by them, according to Goodman and

Anderson, it will be noticed that, in general, the shorter the inhibition time the greater the quantity of short rays. This is more or less true in the case of all the carbons, except K, which with a small amount of short rays is as effective in inhibiting the growth of Staphylococcus aureus as is Carbon C. The inhibition time, as listed above, is sufficiently exact to suggest that there is apparently a definite relationship between the quantity of ultra-violet light of wave-lengths below 290 u.u. and the time of exposure required to inhibit the growth of these organisms. Carbon K, however, is found to be the exception. In studying *Table 2* it is evident that the germicidal effects produced by these carbons are due to rays of wave-lengths 290 u.u. and shorter.

TABLE 3

A comparison of the lethal exposure time and quantity of short rays, given out by Carbon C and the quartz mercury vapor lamp

SOURCE	UNITS BELOW 290 U.U.[1]	LETHAL EXPOSURE-TIME
		seconds
Carbon C	3.197	240
Quartz lamp	6.286	10

[1] Ultra-violet units in ergs per second, per square mm. of area at forty inches, for wave-lengths of 290 u.u. and shorter, according to Goodman and Anderson.

Among others, Harris and Hoyt (4), Houghton and Davis (5), Browning and Russ (6), and von Recklinghausen (7) conducted experiments with Staphylococcus aureus. As these investigators used different methods and omit many data from their reports, it is impossible to compare their results closely. Experimenting with Staphylococcus aureus, von Recklinghausen found the lethal time of exposure to be 10 seconds, when employing a quartz mercury vapor lamp operating at 66 volts and 3.5 amperes, at a distance of 200 mm. from the contaminated surface.

V. GERMICIDAL POWER OF CARBON C AND THE QUARTZ MERCURY VAPOR ARC

To compare the findings for Carbon C with those for the quartz mercury vapor lamp, use may be made of the lethal exposure-time as recorded by von Recklinghausen, and the quantity of rays below

290 u.u. given out by the quartz mercury vapor lamp as listed by Goodman and Anderson, and shown in *Table 3*. These data indicate that the quantity of ultra-violet light of wave-lengths less than 290 u.u., given out by Carbon C, is about half that emitted by the quartz mercury vapor lamp, according to Goodman and Anderson, whereas the lethal exposure-time in the case of the former is twenty-four times as much as that of the quartz mercury vapor lamp. It is therefore evident that the results obtained with the quartz mercury vapor lamp, like those of Carbon K, do not harmonize with the inferences arrived at following experiments with the other carbons.

The spectrum of a quartz mercury vapor arc is not continuous, but has large gaps in it and has more of its energy concentrated at about 250 u.u. and shorter wave-lengths, as compared with the spectra of the carbon arcs.

VI. CARBON K AND THE QUARTZ MERCURY VAPOR LAMP

It is interesting to note that Carbon K, to a great extent, simulates the quartz mercury vapor arc in its spectral distribution, and does this to a greater extent than any of the other carbons.[1] The difference in the results obtained with Carbon K, the quartz mercury vapor arc, and the other carbons, may therefore be due to a difference in concentration of the energy given out by them around 250 u.u. and shorter wave-lengths.

Browning and Russ, using agar surface cultures, found the bactericidal range to be between 296 and 210 u.u., with the maximum between 280 and 250 u.u. Goodman and Anderson recorded the quantity of ultra-violet rays of wave-lengths between 290 and 245 u.u. The results obtained with Carbon K and those of the quartz mercury vapor arc, as given by von Recklinghausen, suggest an extension of the maximal bactericidal range as given by Browning and Russ to include shorter rays, possibly down to 230 u.u. in the case of Staphylococcus aureus.

Many factors may be responsible for a difference in the lethal exposure-time. In comparing the quartz mercury vapor arc with that of Carbon C, as to the lethal exposure-time of Staphylococcus aureus,

[1] Chart on carbons issued by the National Therapeutic Carbon Company.

we find from the data compiled and listed before that there are four important factors to consider:

(a) *The quantity of short waves below 290 u.u.* given off by the quartz mercury vapor arc is, according to Goodman and Anderson, about twice as much as that given off by Carbon C.

(b) The concentration of energy in the case of the quartz mercury vapor arc is greater in the shorter ultra-violet rays around 250 u.u. and shorter wave-lengths. These short wave-lengths seem to be extremely destructive in their action.

(c) The distance of the source of light from the organisms has an influence. In von Recklinghausen's experiments this distance is given as 200 mm., compared with 315 mm. in our experiments with Carbon C. There were therefore, in these investigations, considerable differences in the distance of the organisms from the source of light. If the law of inverse proportions be applied, there would be an appreciable decrease in the intensity of light owing to the greater distance in the case of Carbon C, and thus an increase in the lethal exposure-time.

(d) *The angle of incidence* plays a part. If the direction of the central ray is otherwise than normal to the surface, that is, less than 90°, there should be a diminution in the intensity per unit-area. In the writer's experiments, the angle of incidence was held at 45° in order to keep from the agar media, as much as possible, the ashes that fell from the carbons. In von Recklinghausen's experiments, however, the angle was 90°. This diminution in the intensity would cause an increase in the lethal exposure-time.

All these four factors are therefore seen to aid in prolonging the lethal exposure-time in the case of Carbon C, and are probably responsible for the difference in the exposure time of the two sources.

VII. INFLUENCE OF TEMPERATURE

On contaminating the surface of the agar immediately following the removal of a petri dish from the ice box, and then exposing the contamination as before to the rays emitted by Carbon C, it was found that only after 4 minutes exposure were there any signs of inhibition, whereas controls at room temperature showed inhibition in 15 seconds, as before, and lethal effects in 4 minutes. It is thus evident that

rise in temperature increases the rapidity of the germicidal action of the rays.

The influence of temperature on the action of the rays may be analogous to that observed in photography. Temperature has no effect on photo-chemical action. Thus in taking a picture, the temperature of the room, etc., has no effect on the photograph; on the other hand, the temperature plays a great part in developing the photograph. If the action of ultra-violet light on organisms is a photo-chemical action, one would suspect that, although the temperature would not affect the immediate inhibitory action of ultra-violet light on organisms, it might influence the reactions of the organisms to conditions brought to bear upon them after exposure to ultra-violet light. This being the case, beginning the incubation at a higher temperature after exposure would accelerate the reactions within the organisms, thereby increasing the destructive action upon the organisms and thus decreasing the lethal time.

This explanation, if true, might likewise apply to the therapeutic use of light, for if the irradiated area was kept at a temperature above normal after the irradiation, the physiological reactions of the area would presumably be accelerated.

VIII. INFLUENCE OF AGE OF CULTURE

To determine whether the age of the culture has any influence on the action of the rays, 4-day-old broth cultures were used for contaminating the petri dishes. Exposures to Carbon C at room temperature had no effect on the organisms up to 2 minutes exposure, at which exposure faint signs of inhibition were produced. Older cultures seem, therefore, to be more resistant to the action of the rays.

IX. PENETRABILITY OF NUTRIENT AGAR

When, for experiment, the agar was contaminated before being poured into a petri dish, and exposed as before to Carbon C, growth was present even after 30 minutes exposure. Nutrient agar is not a simple jelly of agar-agar, but contains added proteins and sometimes sugar. It is from these, and not from the agar, that bacteria derive their nutriment. The relative absorption of ultra-violet rays by

proteins, especially the lethal or short rays, is extremely high. The absorption of the lethal rays by the nutrient agar may, therefore, be due to its protein constituents.

X. CONCLUSIONS

Results obtained in this investigation seem to justify the following conclusions:

(1) Carbon C, compared with all the other National Therapeutic Carbons investigated (A, B, D, E, F, G, H, K), has the greatest germicidal effect on Staphylococcus aureus, producing lethal effects after 4 minutes exposure.

(2) As regards Staphylococcus aureus, the germicidal range of the ultra-violet part of the spectrum is confined to 290 u.u. and shorter rays; and the germicidal power is probably at its maximum between 280 and 230 u.u.

(3) The inhibition time for cultures of Staphylococcus aureus irradiated when at considerably less than room temperature is greater than that of contaminations irradiated at room temperature.

(4) Older cultures of Staphylococcus aureus require longer exposure to ultra-violet irradiation to show signs of inhibition.

(5) Nutrient agar is opaque to lethal rays.

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A PRELIMINARY REPORT ON THE RELATION OF DENTAL ACIDURIC BACTERIA TO LACTOBACILLUS ACIDOPHILUS[1]

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Twenty-one strains of aciduric bacteria isolated from *teeth*, and nine strains of known *Lactobacillus acidophilus*, have been studied comparatively in their morphological, biochemical, and serological relations. The dental strains were isolated from the mouths of an unselected group of clinic patients of the School of Dental and Oral Surgery of Columbia University. Inoculations were made into 1 percent glucose meat infusion broth, pH 5.0, and the cultures incubated 48–72 hours at 37°C. All cultures showing Gram-positive rods were streaked on casein digest agar and incubated 48 hours. Typical, faint, punctiform colonies were then transferred back into pH 5.0 broth. Three or four platings were necessary in some cases to obtain pure cultures. Nine strains of known *L. acidophilus* of the *intestinal* type were obtained from several sources as pure cultures. These, and the 21 pure cultures of dental aciduric organisms, were kept growing uniformly in casein digest broth throughout the course of the work.

No consistent difference could be discovered between the groups in any part of this study. On the whole there was indication of a slightly greater *homogeneity* in the intestinal group than in the dental group. This was, perhaps, to be expected from the conditions under which the two groups were obtained. The *appearance* of the growth in broth was found to depend more on the age and extent of the growth than on any intrinsic difference in growth tendency between the groups. All of the strains showed uniform turbidity in the broth at the first appearance of growth; most of the strains of both groups

[1] To be published *in extenso* in an early issue of the *Journal of Bacteriology*.

[2] William J. Gies Fellow in Biological Chemistry at Columbia University, in 1928–29.

proceeded to partial or complete sedimentation within 48 hours. *Gram preparations* revealed no differences between the groups. The type form appearing in the thirty strains was the Gram-positive rod with rounded ends, occurring singly, in chains, and in palisaded clumps, varying rather widely around the mean dimensions of 0.5 × 2–5μ. Chains became shorter in broth from 24 to 48 hours; palisaded clumps predominated on agar. Variant forms, including coccoid, beaded, and curved forms, and filaments, occurred commonly, and with about equal frequency among the two groups of strains. No difference between the groups could be detected in the matter of *colony form.* Both the smooth and the rough forms of surface colonies, and the "X" and "Y" types of deep colonies, occurred so commonly among both the dental strains and the strains of *L. acidophilus* that no differentiation of groups was possible. A considerable variation was noted in colony form of individual strains at different times. In the *fermentation* studies, the two groups showed a similar marked ability to ferment dextrose, lactose, maltose, levulose, and trehalose, and a common inability to ferment raffinose. Salicin and mannite gave variable results with both groups. Saccharose was fermented by only four dental strains and one intestinal strain when first tested, but later all thirty strains acquired the ability to ferment this sugar. All of the strains acidified and coagulated *litmus milk*, most of each group within 7 days. A majority of each group decolorized the litmus in the lower portion of the tubes before inducing coagulation; several of each coagulated the milk before decolorizing the litmus. The limit of *acid production* in casein digest broth, pH 7.4, was similar for the two groups, most of the dental strains producing acidity varying from pH 3.5 to pH 3.8; the intestinal strains, from pH 3.5 to pH 3.7.

Agglutination reactions were studied with sera prepared, against one of the dental strains and one of the intestinal strains, by injection of saline suspensions of living organisms intraperitoneally into rabbits. Each of the thirty strains was put up against the two sera in various dilutions. Most of the intestinal strains, and also of the dental, showed marked cross-agglutination with the serum of the other group.

On the basis of this work the authors see no reason at present for differentiating between the aciduric organisms of dental caries and *L. acidophilus* of the intestine.

BIOCHEMICAL STUDIES OF STREPTOCOCCI

IV. Availability of Nitrogen Compounds[1]

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I. INTRODUCTION

Synthetic media are well adapted for a study of the effects of various added substances. This paper deals with the comparative availability of different nitrogen compounds for the growth of streptococci. The technique was that detailed in a previous paper.[1]

II. METHODS AND RESULTS

1. *Differences in availability of some inorganic nitrogen compounds.* The relative availability of some *ammonium* salts may be clearly expressed in comparative series as follows:

$$(a)\quad (NH_4)_2HPO_4 > \begin{matrix}(NH_4)_2CO_3 \\ NH_4NO_3\end{matrix}$$

Medium 330 (1)[3]: 0.2% $(NH_4)_2CO_3 \cdot H_2O$; 0.01% $MgSO_4 \cdot 7H_2O$; 0.2% mannite; 0.2% KH_2PO_4; 0.02% NaCl; 0.025 cc. NaOH (2.123 M; here and in all similar cases, per 5 cc.). *No growth.*

Medium 331 (1)[3]: 0.2% NH_4NO_3; 0.02 cc. NaOH; 0.02% KH_2PO_4; the remaining constituents of medium 330. *No growth.*

[1] The previous papers in this series were published in this volume (ix, 1929) of the *Journal of Dental Research:* (1) Krasnow and Gies, p. 29; (2) Krasnow and Rosenberg, p. 123; (3) Krasnow and Rosenberg, p. 321.

[2] A preliminary report was published in the *Proceedings of the Society for Experimental Biology and Medicine*, 1928, xxv, p. 664.

[3] Mannite was substituted for the mannose used by Capaldi and Proskauer.

Medium 332 (1)[3]: 0.2% $(NH_4)_2HPO_2$; no KH_2PO_4; the remaining constituents of medium 331. *Growth:* +, +, 4c, in the first three subcultures of the first transplant.

(*b*) $(NH_4)_2HPO_4 > \begin{matrix}(NH_4)_2SO_4 \\ NH_4NO_3\end{matrix} \rangle NH_4Cl$

Medium 202 (3): 0.2% NH_4Cl; 1.0% aspartic acid; 0.175 cc. NaOH (2.123 M). *Growth:* + in the first subculture of the first transplant.

TABLE 1

Rôle of $(NH_4)_2HPO_4$

NUMBER OF MEDIUM	BIBLIOGRAPHY	NaOH 2.123 M	PERCENTAGE COMPOSITION							RESULTS OF GROWTH					
										First transplant					
										Subcultures:					
		Cc. per 5 cc. before sterilization	NH_4NO_3	$(NH_4)_2HPO_4$	$Ca_3(PO_4)_2$	Glycerol	$MgSO_4 \cdot 7H_2O$	Sucrose	$(NH_4)_2SO_4$	1	2	3	4	5	6
544	4	0.09		1.0	0.05		0.5	5.0		2+	0	0	0	0	0
545	4	0.03			0.05		0.5	5.0	1.0	0	0	0	0	0	0
547	4	0.035	1.0		0.05		0.5	5.0		0	0	0	0	0	0
546	4	0.05			0.05	5.0	0.5		1.0	0	0	0	0	0	0
548	4	0.04	1.0		0.05	5.0	0.5			0	0	0	0	0	0
555	4	0.07		1.0	0.05	5.0	0.5			3+	2+	3+	3+	3+	2+

Medium 210 (3): 0.2% $NaNO_3$: 1.0% aspartic acid; 0.18 cc. NaOH. *Growth:* 3+, 2+, in the first two subcultures of the first transplant.

Medium 207 (3): 0.2% $(NH_4)_2SO_4$; 1% aspartic acid; 0.35 cc. NaOH. *Growth:* 4+, +, in the first two subcultures of the first transplant.

Medium 213 (3): 0.2% $(NH_4)_2HPO_4$; 1.0% aspartic acid; 0.167 cc. NaOH. *Growth:* 3+, 3+, 2+, 2+, 2+, in the first five subcultures of the first transplant.

(*c*) $(NH_4)_2HPO_4 > \begin{matrix}NH_4NO_3 \\ (NH_4)_2SO_4\end{matrix}$ (*See Table 1*).

Previously published investigations do not mention findings similar to the above as applied to streptococcus metabolism. However,

Dolt, in his study of about forty simple media for the growth of B. coli (3), chose two as the best, one of which contains $(NH_4)_2HPO_4$ as the sole source of nitrogen. Fermi (4) shows that this ammonium salt is easily utilised by B. prodigiosus and B. fitzianus.

2. *Availability of various amino acids.* The findings are summarized in graded series on the basis of increases in growth and viability.

(*a*) Alanine, Glycocoll > leucine > tyrosine. (*See Table 2*)

(*b*) Glycocoll, Alanine > leucine, aspartic acid > tyrosine

TABLE 2*

Comparison of alanine, glycocoll, leucine and tyrosine

NUMBER OF MEDIUM	BIBLIOGRAPHY	NaOH 2.123 M	PERCENTAGE COMPOSITION								RESULTS OF GROWTH										
											First transplant						Second transplant				
											Subcultures:						Subcultures:				
		Cc. per 5 cc. before sterilization	Alanine	Glycocoll	Leucine	Tyrosine	Mannite	$MgSO_4 \cdot 7H_2O$	KH_2PO_4	NaCl	1	2	3	4	5	6	1	2	3	4	5
314	1	0.04		0.2			0.2	0.01	0.2	0.02	3+	3+	3+	3+	2+	2+	4c	+	2c	+	0
315	1	0.035	0.2				0.2	0.01	0.2	0.02	3+	3+	2+	2+	2+	2+	+	+	3c	0	0
316	1	0.035			0.2		0.2	0.01	0.2	0.02	3+	3+	2+	2+	2+	3+	0	0	0	0	0
318	1	0.035				0.2	0.2	0.01	0.2	0.02	3+	3+	+	0	0	0	0	0	0	0	0

* Capaldi and Proskauer use mannose in these media.

Medium 445 (2): 1.0% glycocoll and 0.038 cc. NaOH (2.123 M). *Growth:* 3+, 3+, 2+, 2+, 2+, in the first five subcultures of the first transplant.

Medium 449 (2): 1.0 % alanine and 0.025 cc. NaOH. *Growth:* 3+, 3+, 2+, +, 2+, in the first five subcultures of the first transplant.

Medium 452 (2): 1.0% leucine and 0.03 cc. NaOH. *Growth:* 3+, +, +, in the first three subcultures of the first transplant.

Medium 458 (2): 1.0% aspartic acid; 0.105 cc. NaOH before sterilization; 0.025 cc. NaOH after sterilization—here and in all similar cases, per 1 cc. *Growth:* 2+, 2+, +, in the first three subcultures of the first transplant.

Medium 453 (2): 1.0% tyrosine and 0.02 cc. NaOH. *No growth.*

These media (445, 449, 452, 458, 453) also contained 0.001%

$FeSO_4 \cdot 7H_2O$; 0.05% $MgSO_4 \cdot 7H_2O$; 0.05% KCl; 0.1% KH_2PO_4; 3.0% sucrose.

(*c*) (1) Aspartic acid > glycocoll > alanine (*See Table 3*)

(2) Aspartic acid, Alanine > glycocoll (*See Table 3*)

(3) Aspartic acid > alanine > glycocoll (*See Table 3*)

(4) Glycocoll, Alanine > aspartic acid (*See Table 3*)

(5) Aspartic acid > alanine > glycocoll (*See Table 3*)

(*d*) Glycocoll > tyrosine > aspartic acid

Medium 526 (6): 1.0% glycocoll; 0.006 cc. NaOH (2.123 M). *Growth:* 2+, 2+, 2+, in the first three subcultures of the first transplant.

Medium 528 (6): 1.0% tyrosine; 0.004 cc. NaOH. *Growth:* 3+ in the first subculture of the first transplant.

Medium 529 (6): 1.0% aspartic acid; 0.09 cc. NaOH before sterilization; 0.015 cc. NaOH after sterilization. *No growth.*

These media (526, 528, 529) also contained 0.2% Ca-glycero-PO_4; 1.5% glycerol; 0.05% $MgSO_4 \cdot 7H_2O$; 0.03% $KHCO_3$; 0.5% NaCl.

(*e*) Aspartic acid = alanine

Medium 96 (7): 0.1% aspartic acid; 0.01% $CaCl_2$; 1.0% dextrose; 0.2% $MgSO_4 \cdot 7H_2O$; 0.1% K_2HPO_4; 0.5% NaCl; 0.002 cc. NaOH (2.123 M). *Growth:* 3+, +, in the first two subcultures of the first transplant.

Medium 98 (7): 0.1% alanine; 0.004 cc. NaOH; the other five constituents being the same as the last five of medium 96. *Growth:* 3+, 2+, in the same subcultures as 96.

(*f*) Histidine > tryptophane > leucine > glycocoll > aspartic acid, glutamic acid, tyrosine (*See Table 4*)

It is interesting to note that the relations are not constant. For example, series *b*, *c* (4), *d* and *f*, show glycocoll as more beneficial

TABLE 3

Comparison of alanine, aspartic acid, and glycocoll

NUMBER OF MEDIUM	BIBLIOGRAFIT	NaOH 2.123 M	PERCENTAGE COMPOSITION													RESULTS OF GROWTH										
																First transplant						Second transplant				
																Subcultures:						Subcultures:				
		Cc. per 5 cc. before sterilization	Alanine	Aspartic acid	Glycocoll	Dextrose	Galactose	Lactose	Maltose	Sucrose	$CaCl_2$	$FeSO_4 \cdot 7H_2O$	$MgSO_4 \cdot 7H_2O$	KH_2PO_4	Na_2CO_3	1	2	3	4	5	6	1	2	3	4	5
235	5	0.15		1.2		0.54					0.021	0.0003	0.024	0.14	0.21	3+	3+	2+	+	+	0	+	1c	0	0	0
241	5				1.2	0.54					0.021	0.0003	0.024	0.14	0.21	4+	4+	0	0	0	0	+	0	0	0	0
247	5		1.42			0.54					0.021	0.0003	0.024	0.14	0.21	3+	0	0	0	0	0	0	0	0	0	0
237*	5	0.13		1.2						0.54	0.021	0.0003	0.024	0.14	0.21	4+	4+	3+	3+	3+	3+	+	0	0	0	+
249	5		1.42							0.54	0.021	0.0003	0.024	0.14	0.21	3+	4+	3+	3+	3+	2+	+	0	0	0	0
243	5				1.2					0.54	0.021	0.0003	0.024	0.14	0.21	2+	+	+	0	0	0	0	3c	4c	0	0
239	5	0.148		1.2				0.54			0.021	0.0003	0.024	0.14	0.21	4+	4+	3+	+	+	0	+	0	0	0	0
251	5		1.42					0.54			0.021	0.0003	0.024	0.14	0.21	3+	2+	2+	+	+	0	0	0	0	0	0
245	5				1.2			0.54			0.021	0.0003	0.024	0.14	0.21	3+	3+	2+	0	0	0	0	0	0	0	0
246	5				1.2				0.54		0.021	0.0003	0.024	0.14	0.21	3+	3+	3+	2+	+	0	3c	3c	2c	0	0
252	5		1.42						0.54		0.021	0.0003	0.024	0.14	0.21	4+	3+	3+	2+	2+	0	0	3c	0	0	0
240	5	0.148		1.2					0.54		0.021	0.0003	0.024	0.14	0.21	4+	4+	3+	0	+	0	+	0	0	0	0
238	5	0.155		1.2			0.54				0.021	0.0003	0.024	0.14	0.21	4+	4+	3+	3+	2+	0	+	4c	0	2c	0
250	5		1.42				0.54				0.021	0.0003	0.024	0.14	0.21	3+	2+	0	0	0	0	0	0	0	0	0
244	5				1.2		0.54				0.021	0.0003	0.024	0.14	0.21	+	0	0	0	0	0	0	0	0	0	0

* NaOH after sterilization = 0.004 cc.

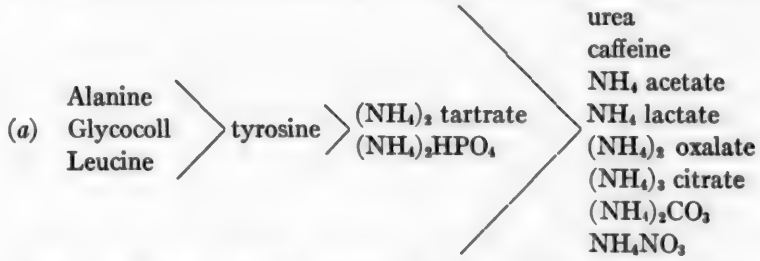
TABLE 4

Comparison of glycocoll, histidine, leucine, tryptophane, tyrosine, aspartic acid, and glutamic acid

NUMBER OF MEDIUM	BIBLIOGRAPHY	NaOH 2.123 M	PERCENTAGE COMPOSITION													RESULTS OF GROWTH										
																First transplant						Second transplant				
																Subcultures:						Subcultures:				
		Cc. per 5 cc. before sterilization	Aspartic acid	Glutamic acid	Glycocoll	Histidine-HCl	Leucine	Tryptophane	Tyrosine	$CaCl_2$	Glycerol	$MgSO_4 \cdot 7H_2O$	K_2HPO_4	KH_2PO_4	NaCl	1	2	3	4	5	6	1	2	3	4	5
116	8	0.04				0.1				0.01	3.0	0.02	0.1	0.1	0.5	4+	4+	4+	4+	4+	4+	+	+	0	0	+
114	8	0.021						0.1		0.01	3.0	0.02	0.1	0.1	0.5	4+	4+	4+	3+	3+	3+	2c	1c	0	0	4c
115	8	0.019					0.1			0.01	3.0	0.02	0.1	0.1	0.5	3+	2+	+	+	0	0	0	0	0	0	0
113	8	0.025			0.1					0.01	3.0	0.02	0.1	0.1	0.5	3+	3+	0	0	0	0	0	0	0	0	0
105	8	0.035	0.1							0.01	3.0	0.02	0.1	0.1	0.5	0	0	0	0	0	0	0	0	0	0	0
107	8	0.032		0.1						0.01	3.0	0.02	0.1	0.1	0.5	0	0	0	0	0	0	0	0	0	0	0
109	8	0.019							0.1	0.01	3.0	0.02	0.1	0.1	0.5	0	0	0	0	0	0	0	0	0	0	0

than aspartic acid. On the other hand, series *c* (1), (2), (3) and (5) show aspartic acid in the lead while glycocoll falls behind. Similar variable effects may be observed for aspartic acid and alanine, and glycocoll and alanine. Tyrosine was always less useful than glycocoll. The relation between tyrosine and aspartic acid is not regular. No more constant results are obtained when the various amino acids are considered from the standpoint of chemical constitution. The explanation for such inconstant behavior is not apparent. One point is evident: No definite conclusion can be drawn as to the comparative utilization of a certain group of compounds when only one basal mixture is considered. As has been shown, the effect of addition of such compounds to a medium, on its availability for the organism, may be very different from the effect of addition of the same compounds to another medium.

3. *Difference in the availability of miscellaneous nitrogen compounds.*



Medium 315 (1): 0.2% alanine; 0.035 cc. NaOH (2.123 M). *Growth:* 3+, 3+, 2+, 2+, 2+, 2+, in the six subcultures of the first transplant; +, +, 3c, in the first three subcultures of the second transplant.

Medium 314 (1): 0.2% glycocoll; 0.04 cc. NaOH (2.123 M). *Growth:* 3+, 3+, 3+, 3+, 2+, 2+, in the six subcultures of the first transplant; 4c, +, 2c, +, in the first four subcultures of the second transplant.

Medium 316 (1): 0.2% leucine; 0.035 cc. NaOH (2.123 M). *Growth:* 3+, 3+, 2+, 2+, 2+, 3+, in the six subcultures of the first transplant.

Medium 318 (1): 0.2% tyrosine; 0.035 cc. NaOH (2.123 M). *Growth:* 3+, 3+, +, in the first three subcultures of the first transplant.

Medium 328 (1): 0.2% $(NH_4)_2$ tartrate; 0.08 cc. NaOH (2.123 M). *Growth:* 2+, 2+, in the first two subcultures of the first transplant.

Medium 332 (1): 0.2% $(NH_4)_2HPO_4$; 0.04 cc. NaOH (2.123 M). *Growth:* +, +, 4c, in the first three subcultures of the first transplant.

Medium 322 (1): 0.2% glycocoll; 0.2% urea; 0.035 cc. NaOH (2.123 M). *Growth:* 2+, 2+, 2+, 2+, +, in the first five subcultures of the first transplant.

Medium 319 (1): 0.2% urea; 0.03 cc. NaOH (2.123 M). *No growth.*

Medium 321 (1): 0.2% caffeine; 0.03 cc. NaOH (2.123 M). *No growth.*

Medium 324 (1): 0.2% NH_4 acetate; 0.04 cc. NaOH (2.123 M). *No growth.*

Medium 326 (1): 0.2% NH_4 lactate; 0.04 cc. NaOH (2.123 M). *No growth.*

Medium 327 (1): 0.2% $(NH_4)_2$ oxalate·H_2O; 0.04 cc. NaOH (2.123 M). *No growth.*

Medium 329 (1): 0.2% $(NH_4)_3$ citrate; 0.06 cc. NaOH (2.123 M). *No growth.*

Medium 330 (1): 0.2% $(NH_4)_2CO_3 \cdot H_2O$; 0.025 cc. NaOH (2.123 M). *No growth.*

Medium 331 (1): 0.2% NH_4NO_3; 0.02 cc. NaOH (2.123 M). *No growth.*

All of these media (315, 314, 316, 318, 328, 332, 322, 319, 321, 324, 326, 327, 329, 330, 331) also contained 0.2% mannite; 0.01% $MgSO_4 \cdot 7H_2O$; 0.2% KH_2PO_4; 0.02% NaCl. Capaldi and Proskauer used mannose instead of mannite.

(*b*) Glycocoll, Alanine, Leucine, Aspartic acid → NH_4 acetate, urea, betaine

Medium 449 (2): 1.0% alanine; 0.025 cc. NaOH (2.123 M). *Growth:* 3+, 3+, 2+, +, 2+, in the first five subcultures of the first transplant.

Medium 443 (2): 1.0% glycocoll; 0.035 cc. NaOH (2.123 M). *Growth:* 3+, 2+, in the first two subcultures of the first transplant.

Medium 452 (2): 1.0% leucine; 0.03 cc. NaOH (2.123 M). *Growth:* 3+, +, +, in the first three subcultures of the first transplant.

Medium 458 (2): 1.0% aspartic acid; 0.105 cc. NaOH (2.123 M) before sterilization; 0.025 cc. NaOH after sterilization. *Growth:* 2+, 2+, + in the first three subcultures of the first transplant.

Medium 442 (2): 1.0% NH_4 acetate; 0.03 cc. NaOH (2.123 M). *No growth.*

Medium 455 (2): 1.0% urea; 0.002 cc. NaOH (2.123 M). *No growth.*

Medium 457 (2): 1.0% betaine-HCl; 0.17 cc. NaOH (2.123 M). *No growth.*

All these media (449, 443, 452, 458, 442, 455, 457) also contained 0.001% $FeSO_4 \cdot 7H_2O$; 0.05% $MgSO_4 \cdot 7H_2O$; 0.05% KCl; 0.1% KH_2PO_4. Sucrose (3.0%) was added to media 444, 445, 449, 452, 455, 457, and 458.

(*c*) Aspartic acid, Alanine

- $(NH_4)_2CO_3$
- NH_4Cl
- $(NH_4)_2HPO_4$
- urea

Medium 96 (7): 0.1% aspartic acid; 0.002 cc. NaOH (2.123 M). *Growth:* 3+, +, in the first two subcultures of the first transplant.

Medium 98 (7): 0.1% alanine; 0.004 cc. NaOH (2.123 M). *Growth:* 3+, 2+, in the first two subcultures of the first transplant.

Medium 93 (7): 0.004 cc. NaOH (2.123 M). *Growth:* 2+ in the first subculture of the first transplant.

Medium 95 (7): 0.1% $(NH_4)_2CO_3 \cdot H_2O$; 0.001 cc. NaOH (2.123 M). *No growth.*

Medium 94 (7): 0.1% NH_4Cl; 0.006 cc. NaOH (2.123 M). *No growth.*

Medium 97 (7): 0.1% $(NH_4)_2HPO_4$; 0.006 cc. NaOH (2.123 M). *No growth.*

Medium 99 (7): 0.1% urea; 0.006 cc. NaOH (2.123M). *No growth.*

These media (96, 98, 93, 95, 94, 97, 99) also contained 0.01% $CaCl_2$; 0.2% $MgSO_4 \cdot 7H_2O$; 0.1% K_2HPO_4; 0.5% NaCl; 1.0% dextrose.

(*d*) Tyrosine, Histidine, Leucine, Alanine

- $(NH_4)_2$ oxalate
- NH_4 lactate
- NH_4 acetate
- NH_4Cl
- urea
- creatine

Medium 680 (9): 1.8112% tyrosine; 0.07 cc. NaOH (2.26 M). *Growth:* 3+, 2+, 2+, in the first three subcultures of the first transplant; 6c, 3c, in the first two subcultures of the second transplant.

Medium 682 (9): 1.55% histidine-HCl; 0.2 cc. NaOH (2.26 M). *Growth:* 2+, 2+, 3+, 2+, 2+, 2+, in the six subcultures of the first transplant.

Medium 683 (9): 1.311% leucine; 0.1 cc. NaOH (2.26 M). *Growth:* 3+, 2+, +, +, +, +, in the six subcultures of the first transplant.

Medium 684 (9): 0.8908% alanine; 0.07 cc. NaOH (2.26 M). *Growth:* 2+, 3+, 2+, in the first three subcultures of the first transplant.

Medium 674 (9): 1.4208% $(NH_4)_2$ oxalate·H_2O; 0.07 cc. NaOH (2.26 M.) *Growth:* 2c in the first subculture of the first transplant.

Medium 675 (9): 1.21% NH_4 lactate; 0.12 cc. NaOH (2.26 M). *No growth.*

Medium 676 (9): 0.7708% NH_4 acetate; 0.12 cc. NaOH (2.26 M). *No growth.*

Medium 677 (9): 0.6004% urea; 0.1 cc. NaOH (2.26 M). *No growth.*

Medium 678 (9): 1.132% creatinine; 0.05 cc. NaOH (2.26 M). *No growth.*

Medium 679 (9): 0.5348% NH_4Cl; 0.1 cc. NaOH (2.26 M). *No growth.*

In addition, these media (680, 682, 683, 684, 674, 675, 676, 677, 678, 679) contained 5.0% glycerol; 0.2724% KH_2PO_4; 0.5% NaCl; $CaCl_2$, trace; $MgSO_4 \cdot 7H_2O$, trace.

(*e*) NH_4 lactate $>$ leucine / tyrosine

Medium 451 (2): 1.0% NH_4 lactate; 0.08 cc. NaOH (2.123 M). *Growth:* 3+, 3+, 3+, 2+, 2+, 2+, in the six subcultures of the first transplant.

Medium 452 (2): 1.0% leucine; 0.03 cc. NaOH (2.123 M). *Growth:* 3+, +, +, in the first three subcultures of the first transplant.

Medium 453 (2): 1.0% tyrosine; 0.02 cc. NaOH (2.123 M). *No growth.*

These media (451, 452, 453) also contained 0.001% $FeSO_4 \cdot 7H_2O$; 0.05% $MgSO_4 \cdot 7H_2O$; 0.05% KCl; 0.1% KH_2PO_4; 3.0% sucrose.

(*f*) Albumen > histidine > tryptophane $\rangle$ leucine / uric acid $\rangle$ glycocoll $\rangle$ aspartic acid, glutamic acid, tyrosine, NH_4 lactate, urea, no nitrogen. (*See Table 5.*)

(*g*) NH_4 acetate / $(NH_4)_3$ citrate $\rangle$ NH_4 lactate / aspartic acid

Medium 571 (10): 1.0% NH_4 acetate; 0.02 cc. NaOH (2.123 M). *Growth:* 3+ in the first subculture of the first transplant; + in the first subculture of the second transplant.

Medium 573 (10): 1.0% $(NH_4)_3$ citrate; 0.11 cc. NaOH (2.123 M). *Growth:* 3+, +, in the first two subcultures of the first transplant.

Medium 572 (10): 1.0% NH_4 lactate; 0.07 cc. NaOH (2.123 M). *No growth.*

Medium 574 (10): 1.0% aspartic acid; 0.118 cc. NaOH (2.123 M) before sterilization; 0.013 cc. NaOH after sterilization. *No growth.*

These media (571, 573, 572, 574) also contained 0.01% $CaCl_2$; 0.02% $MgSO_4 \cdot 7H_2O$; 0.1% K_2HPO_4.

These data may be divided into two groups: Those which show amino acids as better than other nitrogen compounds (series *a*, *b*, *c*, *d*) and those which illustrate the reverse (series *e*, *f*, *g*).

As indicated above, amino acids in some cases were utilized less readily than other nitrogen compounds. But, careful examination of the available data shows that there were comparatively few such instances. Thus, ammonium lactate > leucine, and tyrosine (Series 3*e*); uric acid > glycocoll > aspartic acid, glutamic acid, and tyrosine (*Table 5*); and ammonium acetate = ammonium citrate > aspartic acid (Series 3*g*). These comparisons mean that ammonium lactate, uric acid, ammonium acetate, and ammonium citrate support the life of the organism longer than amino acids. It may be well, at this point, to draw the reader's attention to the finding: Albumen > histidine > tryptophane > leucine, and uric acid > glycocoll > aspartic acid, glutamic acid, and tyrosine (*Table 5*). Although albumen per se is not classed as an amino acid, amino acids are easily liberated from it. The writers feel that this result is due to the presence of derived substances in the autoclaved albumen medium, amino acids among them. Therefore, in these experiments, albumen may be classed among the amino acids. There are then altogether three

TABLE 5

Comparison between amino acids and other N compounds

NUMBER OF MEDIUM	BIBLIOGRAPHY	NaOH 2.123 M	PERCENTAGE COMPOSITION																	RESULTS OF GROWTH										
																				First transplant						Second transplant				
																				Subcultures:						Subcultures:				
		Cc. per 5 cc. before sterilization	Albumen	NH_4 lactate	Aspartic acid	Glutamic acid	Glycocoll	Histidine-HCl	Leucine	Tryptophane	Tyrosine	Urea	Uric acid	$CaCl_2$	Glycerol	K_2HPO_4	KH_2PO_4	NaCl	$MgSO_4 \cdot 7H_2O$	1	2	3	4	5	6	1	2	3	4	5
5Bp*	8	0.03	0.1											0.01	3.0	0.1	0.1	0.5	0.02	4+	4+	3+	3+	0	0	2+	3+	3+	2+	2+
116	8	0.04						0.1						0.01	3.0	0.1	0.1	0.5	0.02	4+	4+	4+	4+	4+	4+	+	+	0	0	+
114	8	0.021								0.1				0.01	3.0	0.1	0.1	0.5	0.02	4+	4+	4+	3+	3+	3+	2c	1c	0	0	4c
115	8	0.019							0.1					0.01	3.0	0.1	0.1	0.5	0.02	3+	2+	+	+	0	0	0	0	0	0	0
112	8	0.023											0.1	0.01	3.0	0.1	0.1	0.5	0.02	2+	2+	3+	3+	+	0	0	0	0	0	0
113	8	0.025					0.1							0.01	3.0	0.1	0.1	0.5	0.02	3+	3+	0	0	0	0	0	0	0	0	0
105	8	0.035			0.1									0.01	3.0	0.1	0.1	0.5	0.02	0	0	0	0	0	0	0	0	0	0	0
106	8	0.017		0.1										0.01	3.0	0.1	0.1	0.5	0.02	0	0	0	0	0	0	0	0	0	0	0
107	8	0.032				0.1								0.01	3.0	0.1	0.1	0.5	0.02	0	0	0	0	0	0	0	0	0	0	0
109	8	0.019									0.1			0.01	3.0	0.1	0.1	0.5	0.02	0	0	0	0	0	0	0	0	0	0	0
111	8	0.019										0.1		0.01	3.0	0.1	0.1	0.5	0.02	0	0	0	0	0	0	0	0	0	0	0
158	8	0.018												0.01	3.0	0.1	0.1	0.5	0.02	0	0	0	0	0	0	0	0	0	0	0

* 5Bp also permitted growth, 2c, 2c, +, +, in the four subcultures of the third transplant.

instances in which the four "non-amino acid" substances were better than amino acids. On the other hand, most of the latter were better than most of the former. This is well illustrated in Series 3 (*a*, *b*, *e*, and *f*). Alanine, glycocoll, leucine, tyrosine > ammonium acetate, ammonium carbonate, ammonium citrate, ammonium lactate, ammonium nitrate, ammonium oxalate, ammonium mono-hydrogen phosphate, ammonium tartrate, caffeine and urea; glycocoll, alanine, leucine, aspartic acid > ammonium acetate, betaine and urea; histidine, tryptophane, leucine and glycocoll > ammonium lactate and urea. The contrast is clear. It is evident that, in general, amino acids supply the nitrogen needs of streptococcus better than other nitrogen compounds.

As in the case of carbon compounds, some added nitrogen substances caused no effect on growth. Thus, ammonium carbonate, ammonium chloride, ammonium mono-hydrogen phosphate, and urea, were not beneficial (Series 3*c*). The same was found for the tests in *Table 5:* aspartic acid, glutamic acid, tyrosine, urea, uric acid, and ammonium lactate did not aid maintenance.

In another set of experiments we used as the basic mixture: aspartic acid, 0.2 per cent (0.015 M); $MgSO_4 \cdot 7H_2O$, 0.0036 per cent (0.0001 M); and K_2HPO_4, 0.1 per cent (0.00575 M). The aspartic acid of this medium was substituted by 70 different nitrogen compounds, making as many different media. Among them were included substances containing all types of nitrogen. The *inorganic* compounds were ammonium chloride, ammonium carbonate, ammonium nitrate, ammonium sulphate, ammonium molybdate, ammonium thiocyanate, ammonium acetate, ammonium benzoate, potassium nitrate, sodium nitrite, sodium nitrate, ferric nitrate, lead nitrate, magnesium nitrate, silver nitrite, silver nitrate, zinc nitrate, ferrous ammonium sulphate. Fifty-two *organic* compounds were included: urea, hydroxylamine hydrochloride, acetamide, urethane, ethylamine, aniline, aminophenol (ortho and para), phenylenediamine hydrochloride (meta, para, and ortho), benzidine, arsphenamine, neosalvarsan, anthranilic acid, sulfanilic acid, phenylhydrazine hydrochloride, acetanilid, creatine, creatinine, hippuric acid, phenacetine, saccharin, caffeine, indol, skatol, pyrrol, pyridine, quinoline, hexamethylenetetramine, azobenzene, nitromethane, nitrophenol, nitrobenzene para-nitrosodimethylaniline, brucine sulfate, quinine bisulphate,

strychnine, strychnine sulphate. Several *dyes* were included: aniline blue (triphenylrosaniline hydrochloride), chloramine-T, congo red, crystal violet, indigo, malachite green, methyl orange, nitraniline (meta and para), picric acid, sodium alizarin sulfonate.

Only six of these compounds permitted the streptococci to remain viable for one or more days. Anthranilic acid was the best among them. The other five were ferric nitrate, ferrous ammonium sulphate, indigo, magnesium nitrate, and neosalvarsan.

In ascertaining the availability of the various substances, we ran controls on each. We added the test substance to beef infusion broth, in the proportions used for the synthetic media. Silver nitrite, silver nitrate, zinc nitrate, lead nitrate, sodium nitrate, aminophenol (ortho, meta, para), paraphenylenediamine hydrochloride, hexamethylenetetramine, malachite green, hydroxylamine hydrochloride, alizarin, para-nitrosodimethylaniline, quinine bisulphate, brucine sulphate, and aniline blue inhibited the growth of streptococci in nutrient broth.

III. CONCLUSIONS

The findings of chief interest are these:

(a) Ammonium mono-hydrogen phosphate led the other inorganic nitrogen compounds in nutritive value for streptococci.

(b) The differences in the availability of various amino acids were not constant.

(c) Amino acids in general were superior to the other nitrogen compounds as sources of nitrogen for streptococci.

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PROBLEMS IN TEACHING PRE-CLINICAL SUBJECTS, WITH SPECIAL REFERENCE TO THE PREPARATION OF THE STUDENT FOR RESEARCH[1]

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The problems involved in the teaching of pre-clinical subjects are essentially the same, whether they are taught to medical students or to dental students. There is only a difference in the choice of clinical application and of illustrative material, and in the emphasis placed on phases of special interest to the dental or medical profession. We all agree that we must establish and maintain close coöperation between the medical and dental professions, for in the last analysis the dentist does not treat the tooth cavity alone, but he treats the patient, just as the physician does not treat merely a particular disease, but rather a given patient. Dental students should become acquainted with this relationship early in their training, and there is no better time to emphasize it in their minds than when teaching the pre-clinical subjects. These subjects, although by tradition they have come to be called "medical," are just as much dental as medical. When our students learn to realize this, they will not resist the teaching of such so-called medical subjects as anatomy, physiology, and biochemistry, and they will understand that they have common interests with the medical students.

Unfortunately many dental students are still reluctant to offer their best efforts to the study of the pre-clinical subjects. But in justice to the students, it must be said that they are least to be blamed for this attitude. The old time dentists have coached them to underestimate the value of the theoretical subjects. This wrong attitude has also been nurtured inadvertently by dental teachers who have failed to

[1] Read at a session of the Seventh Annual Meeting of the International Association for Dental Research, Northwestern University Dental School, Chicago, Ill., March 23–24, 1929. See abstract: *Journal of Dental Research*, 1929, ix, p. 281.

grasp the broad medical view, and by medical teachers who have looked down upon the dental profession and have been indifferent to the best interests of the dental students. Medical and dental progress will advance, as Dr. F. B. Noyes has well said, "in proportion to the increase in the number of dentists who have a medical viewpoint, and the number of physicians who have a dental viewpoint."

One of the common problems in teaching pre-clinical subjects is that of correlation. The responsibility for correlating the subjects of a given curriculum must be shared equally by all departments. Pre-clinical teaching should anticipate clinical instruction. Clinical teaching, in turn, should be based on facts observed and studied in the theoretical courses. Intelligent association of two subjects affords reciprocal value to both. The efficacy of correlation is definitely limited by the time alloted to the course, by the scope of the student's knowledge, by the amount of coöperation among the departments concerned, and by the extent to which the instructor has mastered not only his own subject, but also the subjects with which his course is associated. For the sake of simplicity, correlation may be classified into three types: (*a*) correlation among pre-clinical subjects; (*b*) correlation among clinical subjects; and (*c*) correlation between the pre-clinical subjects on one hand and clinical subjects on the other.

(*a*) In considering correlation among pre-clinical subjects we find that in the case of histology, for example, correlation is not only desirable, but becomes almost a necessity. The close relationship between gross and microscopic anatomy is most evident. But in order to vitalize histology, we must correlate it with biology and particularly with physiology. Without it histology becomes lifeless. Some schools have found it advisable to give special correlational courses. That there is great room for improvement in the correlation among pre-clinical subjects may be seen from the reaction of fifty students to a problem question included in a recent final examination in dental histology. The question was: "Supposing that you have developed a new method of root-canal treatment, how would you produce evidence to show that your method is biologically correct?" A majority of the students replied that they would first try their treatment on teeth of lower animals and then, after varying intervals of time, kill the animals, and make histologic sections of the apical and periapical regions of

the teeth. Some would in addition x-ray the teeth at varying intervals. Some insisted on the importance of clinical observation. However, among the fifty students of this class who studied bacteriology at the same time, there was only one who thought of applying bacteriology in the solution of this problem. This student planned to remove the pulp of an apparently normal tooth, carrying microörganisms into the root canal, then treating the canal, and later learning histologically whether or not his treatment succeeded in combatting the infection.

(*b*) In considering the second type of correlation—that among the clinical departments—we find the outlook much more promising. It is to the credit of the clinical departments that the various steps of procedure in the infirmary are, in most cases, so systematically organized that a student cannot help but correlate the teachings and principles of every clinical department in the case of each patient. With the exception of emergency cases, the student must study his patient from the viewpoint of general health, and from the viewpoint of each clinical department, and must complete a comprehensive diagnosis before he is allowed to begin treatment of the case. The extraction of a tooth for prosthetic reasons only after the root canal was treated and a crown placed on the tooth, because of incomplete diagnosis, is in our opinion a thing of the past.

(*c*) The third type of correlation—that between the preclinical and clinical subjects—also deserves careful consideration. In correlating, for example, histology with operative dentistry, we not only aid the student in rationalizing his operative technique, but we also help him in his appreciation of the histologic facts without an overdependence on mere memory. Our histology department has been fortunate in securing the coöperation of the heads of the clinical departments, who have lectured to the dental histology classes on the application of histology to their respective specialties.

Our students are not purists in science. They are inclined to evaluate the information they obtain in terms of practical usefulness. When the class finds that the importance of the facts emphasized by the histology instructor is corroborated by their clinical teacher, each student evinces a deeper appreciation of these facts. Correlation, in addition to its immense intrinsic value, may perform another important function. The story is told of a famous preacher who would

inject into his sermon a startling or humorous remark whenever he saw any of his audience fall asleep. When employing the lecture method, we find that nothing affords the student more mental stimulation than the correlation of a fact to a clinical practice or experience. There is nothing that can be a greater incentive to the student's interest and concentration than the association of a fact with a situation that might occur in the misty Utopia which the student dreams of entering the day after he graduates.

The relationship between teacher and student is another important factor. The personal equation necessarily enters into this problem. However, if we as teachers expect to gain the respect of the students, we must in turn show respect to them. Except for his knowledge in the instructor's particular field, the student is, as far as we may judge, in every way the equal of the instructor and should be treated as such. The application of the Golden Rule in teaching would solve many problems that come up between teacher and student. The tendency of some teachers to give their lectures or demonstrations, and then let the student sink or swim is in our opinion wrong. We must help the student to find himself in our courses and, above all, encourage him to develop a spontaneous interest in each subject.

Practical education has been defined as instruction that imparts first what is necessary; secondly, what is useful; and thirdly, what is ornamental. The beginning student cannot be expected to differentiate among the necessary, useful, and ornamental facts. The teacher should guide this differentiation. Above all we are obligated to impart to the students a practical and working knowledge of the subjects we teach. This is essential in medical and dental education, where the student is to acquire not only general cultural development, but also sufficient preparation and training to perform intelligently his particular function when the health of the community is entrusted to his hands and judgment.

A word about grading may not be amiss at this point. Grading should be relative. In most cases classes follow the law of averages and conform to the normal frequency curve. If certain students stand out prominently in their class they are entitled to the highest grade that can be given. The student is entitled to the benefit of the doubt, and should be commended whenever he deserves it. When a

considerable percentage of a class fails or is close to failing, part of the responsibility rests on the teacher.

There are two schools of thought in respect to methods of teaching. One school champions the older and more systematic way of teaching by lecture, demonstration, and laboratory. This type may be called methodic teaching. The other school, inspired by the new era of research, advocates what may be called the research method of teaching. The *methodic school* believes in giving a systematic and comprehensive course concentrated on fundamental facts and relationships. The instructor assumes a certain responsibility for imparting this information. Since science is organized knowledge, he sees to it that the basic facts are well organized in the mind of the student. The instructor helps the student to get the factual material, outlines and supervises his laboratory work, and gives definite assigments. This method is for the mass of the student body, and trusts that the born scholar and scientist will progress in spite of the limitations of the method. In the *research method*, the seminar type of instruction is employed. The responsibility of obtaining fundamental facts rests entirely on the student. The instructor acts as a guide in discussion, and impresses the student with the lack of definite knowledge in many fields. He takes it for granted that the student knows the basic facts. He is not interested in how the student obtains this information. He may occasionally suggest reading in current periodicals, but gives no definite assignments. He regards the lecture as an antiquated method, and devotes his lecture hour to a discussion of controversial problems and recent investigations. Research is his idol.

It is our opinion that the research method of teaching is ideal for graduate or elective courses, but ineffective and wasteful when employed in the teaching of the sciences to beginners. Discussion is an excellent method of study. But we must remember that the *sine qua non* of discussion in facts. A discussion without facts is merely a vocal exercise. How can we expect students to discuss intelligently the more advanced problems of any science before they have mastered the fundamental facts that form the basis of that science? We know of a man who came to this country without any knowledge of English and who started to study our language by buying a dictionary and a complete set of Shakespeare's plays. He had infinite patience and

worked like a Trojan, and yet made very slow progress in English. We can readily understand why. He violated the most important principles of pedagogy. Instead of proceeding from the simple to the complex, and from the concrete to the abstract, he reversed this process and failed. Are we not following this man's footsteps when we expect our students to appreciate and understand research before we help them get the A-B-C and grammar of science? When an instructor employs the research method of teaching with beginning students, he usually talks over the heads of most members in the class, and thus not only wastes his efforts but also discourages and sometimes bores the students.

In the teaching of general and dental histology, we try to avoid the research method of instruction, except for occasional references to investigations that are being carried on at the present time and to the possibilities of research in certain directions. We employ the laboratory method and find it effective. Professor Minot has defined the ideal of laboratory education as that method which first directs the student's attention to actual original observations made by himself; which, secondly, aids him in drawing correct conclusions from these observations; and which, thirdly, enables the student to say at the end of the course that he knows of his own knowledge. This ideal should be approached as nearly as possible, but practical considerations compel us to compromise. The laboratory method consumes so much time that the student must depend also on information which comes from the experience of others. Our heritage of knowledge is so vast that fortunate is the man indeed who has caught a comprehensive glimpse of it, and blessed is he who can bring an offering to it. But men, including both students and teachers, are not always fortunate and not often blessed, so that we must resort also to the more humble means of learning by lecture, and book, and discussion. In lecturing we try not merely to present important facts, but also to vitalize and personify these facts. In histology, for example, we recognize the cell as a unit of structure. But each cell is also a unit of function and a living being. If we are able to inspire the student to the point of recognizing the cell as a personality, and of respecting it as such, his work will be more fruitful and interesting.

In our dental histology, we include a short course in general and

dental embryology. In order to vitalize the laboratory work, each student is furnished with pig embryos of various stages of development for gross examination and dissection purposes. The student can thus observe the various steps in the development of the face and jaws. In addition, the student is also furnished with microscopic sections of similar embryos. However, in spite of the fact that we concentrate on the laboratory method, we find it necessary to employ the lecture method as well. The student in his earnest effort to understand the various steps an animal passes through during development, may miss the forest among the many trees, and thus lose his true reward—the pleasure and joy that comes from an intelligent appreciation of the beautiful unfolding of nature manifested in embryology. Throughout the various developmental stages there reign certain biologic principles which, when understood, help to clarify the facts and integrate the parts into one harmonious whole. An introduction to these biologic principles must be supplied by the instructor in the form of lectures.

In discussing the preparation of students for research we must bear in mind that there cannot be a prescribed course that will prepare one for research. Such a course may add a unit of credit to the student's record but will do little more. Research involves a consummation of qualities and attitudes that transcend the usual methods of teaching. There are several methods that may be employed in undergraduate teaching to help pave the way in the right direction. The requirement of reports to be prepared on special topics helps to interest the student in the literature and the original sources. Elective courses make it possible for the student to delve more thoroughly into special problems and to become more adept in experimental technique. Occasional references by the teacher to the historical developments that finally culminated in an epoch-making discovery, or to the struggles and triumphs of great investigators, may at times inspire a few students to develop a deeper interest in research problems. The employment of select undergradute students to assist in the investigations of graduate students or faculty members may initiate some into the realm of scientific inquiry.

But more important than any or all of these methods is the cultivation of an atmosphere of scientific inquiry that should permeate the

lecture halls, the laboratories and the clinics. A hunger for knowledge, a passion for truth, a keen power of observation, an infinite patience, are among the qualities essential to research. These qualities cannot be made to order nor are they acquired overnight. They must come from within, and must be developed and cultivated throughout the entire college career side by side with the teaching of the prescribed courses of study. Though each student must depend to a considerable extent on information from the experience of others, it is essential that he be encouraged and given the opportunity to learn of his own knowledge, and to start at times the study of a particular structure or process without any preconceived ideas from text books or lectures, and thus to arrive at his own independent conclusions. Such procedure involves the trial and error method of study, and is time consuming, but offers a fertile field for instilling in some students a desire for further study and investigation. Rather than to "crowd" a course and stifle the student's opportunity to search for himself, it is far better to omit certain phases of the subject and thus free some time for slow, careful, and spontaneous observation and reflection.

Since research must be thorough, the student's undergraduate preparation must be thorough. Each course must be so organized and conducted that the total impression produced by all the courses on the student's mind at the time of graduation should be one of appreciation and pleasant recollection. His reaction should be such that he desires more than ever before to continue study and investigation along lines of special interest. There have been too many students who marked their graduation day not as a commencement of a life, with greater opportunities for study and participation in the progress of their profession, but as a riddance of a necessary evil and a farewell to books and studies.

The responsibility for instilling in the students an appreciation of and a desire for research rests on all departments, and on every member of the faculty. A teacher of course cannot share in the cultivation of an atmosphere of research, if he himself is not imbued with it. The establishment of a research department is sound, but insufficient if it is not supported and fed by the other departments. No one department can have a monopoly of research, and the tendency of some schools to shift the responsibility for research to a denominated depart-

ment will not solve our problem. We do not expect that every student will eventually become a research man. We know that only a very small percentage will actually do research. But it is equally important that we inculcate in the minds of all students an appreciation of and respect for research, so that they may respond to the echoes that come from the research laboratory and eagerly await the findings of research and help to test their application.

Regardless of how many or how few of our students will follow research after they complete their undergraduate work, it is paramount that, in the words of Professor Theobald Smith, we create in our students "faith in the ultimate triumph of science over the problems and mysteries of disease."

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THE HISTORICAL SIGNIFICANCE OF PROFESSOR GIES' 1927 STUDY IN THE STOMATOLOGIC MOVEMENT[1,2]

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Introductory note. "Education" of the laity in professional matters has often been condemned as "advertizing." Education of the profession along lines not in accord with the views of those in power, as in the case of the stomatologic movement, has been considered "propaganda." Articles and reports have thus been published *with* and *without* important information as expediency demanded, in order that they may be *free* from propaganda.

The dental press in America is still dominated by "dental autonomists" and "vested interests," and *their* education or propaganda has had an uninterrupted history. The logical outcome was an embargo on stomatologic ideas and the suppression of articles dealing with stomatology by those connected with the stomatologic movement. The leadership of the stomatologic movement in America thus found itself forced, after six years of strenuous effort to get a hearing before the dental and medical professions, to establish the *American Journal of Stomatology*, an independent journal free from any affiliation with any special group or society, to impartially record the events and developments in the professions as they affect the stomatologic movement.

A disturbing factor was the "organized" opposition of influential members of the professions to break down the movement with methods not at all complimentary to professional men, American traditions, and civilized persons living in an age of progressive thought and action. The attack on "personalities," slander, unfounded rumors, and employment of other measures of "social pressure" against practitioners affiliated with the movement,

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[1] Annual report read before the Sixth Anniversary Meeting of the Stomatologic Movement in America, under the auspices of the American Society of Stomatologists, Hotel McAlpin, New York, City, May 3, 1929.

[2] This *Journal*, from the beginning, has represented an unwavering purpose to keep widely open the channel to freedom of responsible and respectable expression of truth and opinion in dental affairs, by individuals or organizations, without qualification by or for any views its editors individually may entertain. In accordance with this purpose, the manuscript of this paper, received on June 13, 1929, was accepted for prompt publication, regardless of its title and its length, and appears here as presented. Dr. Asgis, the leader of the "stomatologic movement" in North America, is thus afforded unhindered opportunity to publish his committee's report to the American Society of Stomatologists. The printer's proof has been corrected by Dr. Asgis. Responsive comment will be published in a succeeding number of this *Journal*. Several misapprehensions and inaccurate statements of fact, however, which Dr. Asgis would not wish to circulate without prompt correction, are briefly noted on page 595 of this issue.—[*Ed.*]

are most embarrassing, were they to be known. As late as May 25, 1929, such "rumors" were *the only* factor that made it necessary for a leading member of a leading university dental faculty to refrain from continuing to lend his support to the movement and to be officially identified with our activities.

It is therefore with great satisfaction, for the good name of our specialty, that I express, on this occasion, our gratitude to several dental journals, notably the *Aider-er*, the *American Dental Surgeon*, and medical journals, the *Medical Journal and Record*, and *Clinical Medicine and Surgery*, for their progressive attitude toward our movement. It is with pride that we may now point to a journal not devoted to "propaganda," to a journal dedicated to dental research exclusively, the *Journal of Dental Research*, which has opened its pages to a presentation of a phase of the stomatologic movement that I hope will be of practical interest to dentists and physicians alike.

Personally, I wish to thank Prof. Gies for the privilege afforded me to present some of the views on educational reform in this *Journal*. In my relationship with Prof. Gies in the past, through personal contact and correspondence, I can say that I have always admired his readiness to serve the best interests of the profession and accord others, who disagreed with him, a fair chance. I am indeed pleased to be able to state that his position toward the stomatologic movement, as exemplified in this instance, brings honor to Prof. Gies personally and to the profession as a whole.

As a subject for my Annual Report on Stomatologic Education I have chosen Prof. Gies' 1927 study (1).[3] Dr. Gies' study may most appropriately be introduced with the following statement by Dr. Clarke on the difficulty of conveying ideas:

"Exchange of thought through the medium of words is hedged about by difficulties which stamp informal conversation definitely as an art and not as a science. In other words the *idea* in the mind of the speaker is transmitted through language, not pure and untainted and 'under seal,' as we should wish, but tinged and twisted and disfigured. This is partly due owing to the inherent imperfections of language and of our conventional method of translating thought into words, and partly to personal idiosyncrasies of the minds of both speaker and listener. These latter operate to cause the speaker to say something different from what he is thinking, and the listener to construct in his mind an idea different even from that implied in those inaccurate words" (2).

[3] This report has been revised for publication in this *Journal*, omitting non-essentials. The term "study" is here used, in preference to "Carnegie report" or other designations, for the sake of clearness. The "study" is a report *by* Prof. Gies *to* the Carnegie Foundation for the Advancement of Teaching and not a *Carnegie* Report. Prof. Gies calls our attention to the distinction between the Carnegie *Corporation* and the Carnegie *Foundation* (*Dental Cosmos*, July 1928, p. 712), which is often overlooked. "Bulletin No. 19," or "Bulletin," is used for "study" interchangeably in this discussion.

Our profession has not devoted sufficient time necessary to be versed in matters educational. We may, therefore, not expect the dental practitioner to be an able or qualified judge of a work which has been characterized as a contribution that "marks the beginning of a new era in the progress of dentistry" (Midgely; 3). Prof. Gies' study on dental education, issued by the Carnegie Foundation for the Advancement of Teaching on June 27, 1927, covers a vast field and a variety of subjects, too difficult and too complex for the general reader not familiar with historical, educational, and pedagogical issues pertaining to dental matters, to form a sound judgment. Bulletin No. 19 becomes more difficult to understand because of its *newer terminology*. While it is true that newer *concepts* or *ideas* necessitate the creation of new symbols to accurately transmit or convey them to the listener, they at the same time present newer difficulties during the process of transmission to the listener. It is with the object of conveying to you the *meaning*, the *idea* or *ideas*, as I understand them, contained in Prof. Gies' 700-page volume (Bulletin No. 19) that I deem it necessary to re-translate some of the "terms" used in his study into conventional language. It shall be our priviledge to discuss the Bulletin in the same spirit in which it was written:

"It should be clearly recognized that actualities rather than labels or symbols are the important factors in a consideration of this situation." (Bulletin, page 13.)

We should all feel regretful that Prof. Gies was unable to accede to my request to be here with us this evening and give us *his* comment on my interpretation of his study on dental education. The many correlated aspects of the problems dealt with in this elaborate work, the first of its kind in America and probably in the world, make it humanly impossible to dwell on some details considering the limited time at our disposal. And yet a detail, insignificant to us, may be most important to a proper evaluation of the study in its entirety. This could more adequately be observed by Dr. Gies himself. I am, therefore, compelled to rely entirely upon the cold facts and statements presented in the study. Let us, nevertheless, endeavor to penetrate the *spirit*, rather than adhere to the word, that permeates this study and let us try to get the "meaning" behind the mere sym-

bolism that language presents. It must be said, at the very outset, that the language in the Bulletin, in which complex ideas are carefully dressed and terms specially designed for hitherto ambiguous conceptions of dental situations, at once conveys the impresson that the author has taken very painstaking efforts to present a scholarly analysis, a consistent theory, and a realistic portrait of prevailing *dental educational opinion*. Prof. Gies may be congratulated on having been the first throughout the world, to my knowledge at least, who has so successfully carried out his task. The "dental autonomous" doctrine has received in the hands of no one else up to the present time, a treatment so masterful, so subtle, and so penetrating as it did in the hands of Dr. Gies in the Bulletin. This adds to its historical value and calls for a careful analysis in terms of the stomatologic doctrine.

But we must not confuse historical values with purely abstract or theoretical values. Neither must we think of "history" in terms of "chronology," mere sequence of events. From such a viewpoint, it is premature for us to deal with Prof. Gies' 1927 study. We must also differentiate the *educational* and *social* values of the Bulletin from its *historical* value, in the sense in which I propose to deal with it here. I had occasion to refer to Prof. Gies' efforts in dental education in connection with the history of American stomatology (4) and dental educational reform in the United States (5). This evening, our interest lies in determining the organic unity of our specialty in its evolution, since 1839, along bio-medical lines toward the end of ultimately establishing itself as a specialty of medicine. It is from this viewpoint, i.e., how does the study fit into this chain of historical unfoldment of American dentistry in the direction of its emergence into a medical specialty in every respect, that the Bulletin needs our serious consideration. Its historical value, as will be shown, will also disclose its practical value to the stomatologic movement.

Prof. Gies' study, published as "Bulletin No. 19" in 1927 by the Carnegie Foundation for the Advancement of Teaching, would present little of practical significance to the stomatologic movement in America, if it represented, as indicated on its title page, merely a report *to* the Foundation. Reports and investigations have from time to time been undertaken by various social and educational agencies,

and such reports have been published and distributed *by* and *to* the parties concerned. Let us assume that the Carnegie Foundation was interested in dental education; that it appointed Prof. Gies in 1921 to carry out the study for them; that in 1927 the survey was completed; that it was issued by the Foundation, the same year, as Bulletin No. 19; and there the matter ends. Since this Bulletin represents only an *educational report* and not a technical study of either medicine or dentistry, it might be more advantageously used by educators and, probably, by some physicians or dentists who might also be interested in dental educational questions. If such were the case, the Bulletin might not claim to deserve such a prominent place on our annual program, at the sixth anniversary meeting of the stomatologic movement in America, two years after the Bulletin had been in circulation; and especially when comments and interpretations on the study have appeared in most leading dental and medical journals (and the lay press) in the world.

It is well to bear in mind that were the *same study*, conducted by Prof. Gies, to appear either under the auspices of a less influential organization socially, or a less disinterested body—for example, a dental organization—its effects might not have been felt as keenly. The *influence* of this study, by virtue of its appearance under such influential auspices as the Carnegie Foundation for the Advancement of Teaching, is more far reaching than were the same study to be issued by a less representative organization. The influence on the rank and file of dentists and physicians, on public opinion, on the opinions of those directing the educational world, is now beginning to show the effects. The use made of this study by "dental autonomists" for propaganda purposes, to perpetuate the "dental autonomous system" of education for dentists in the United States and Canada, lends added importance to the Bulletin and its significance in the stomatologic movement of today.

Before we may intelligently discuss the subject proper of the evening, it is essential for us to be clear, or at least set out with a definite understanding, regarding certain subjects related to the study. Let me briefly touch on four points of interest:

(*a*) What does the Bulletin represent?

(*b*) Is the terminology clear?

(*c*) Who was the study prepared for?

(*d*) What are the *points of contact* between the Bulletin and the stomatologic movement in America?

(*a*) In my address before the annual meeting of the Maryland State Dental Association in April 30, 1928, I pointed out, among other things, that the Bulletin represents the personal opinion of Prof. Gies about education in dentistry in America and the opinions of dental educators who uphold the dental-autonomous doctrine (6, 7).[4] It does not represent the stomatologic viewpoint. We may probably get a clearer conception from a statement by Prof. Gies himself:

"The Bulletin consists of a 'Report *to* the Carnegie Foundation,' and a Preface in general allusion to it. If there were any dictation in the report, it would be dictation to the Carnegie Foundation by the author of the report. The Preface, by the President of the Foundation, commends the report to public notice, nothing more. The report presents facts, findings, opinions and recommendations, unattended by any power of enforcement—a very poor basis for expectant dictatorship." (8).

(*b*) The terms used, either separately or in sentences and paragraphs, leave one in doubt as to their exact meaning. Of the terms that are so confusing, I may enumerate the following: *Health service, medicine, division of health service, dentistry, oral health service, stomatology, practice of medicine, practice of dentistry, oral specialty of the practice of medicine, types of dental practitioners, general practitioners and oral specialization, physician, dentist, stomatologist, oral surgeon, etc., conventional medicine, clinical medicine, clinical dentistry, medico-dental subjects, mechanics, esthetics, medical profession, dental profession, medical sciences, dental education, dental educational problem, 2-3 plan, 2-3-graduate plan, and dental curriculum.* Of all these terms,

[4] My address, "The bio-medical direction of dental practice as a guide to the fundamentals of stomatology," was read at the general session of the annual meeting of the Maryland State Dental Association, in Baltimore, April 30, 1928. It was discussed by J. M. Rowland, M.D., Dean, Medical School, University of Maryland, and J. Ben Robinson, D.D.S., F.A.C.D., Dean, Baltimore College of Dental Surgery, Dental School, University of Maryland. The papers read before that Association are usually published in the *Dental Cosmos*, to which journal my paper was sent by the Secretary of the Association. After a lapse of time, I was informed by the editor that it was not suitable for publication in that journal. An abstract of the paper appeared in the "fourth stomatology symposium," *Medical Journal and Record*, March 20, 1929.

"stomatology" and "oral specialty of the practice of medicine," need be assigned a definite meaning in our present discussion. According to Prof. Gies:

"Dentistry is 'oral health service,' which as a descriptive term, is synonymous with 'stomatology.' For laymen, oral health service is not a term of mystery like stomatology" (9).

Elsewhere, Dr. Gies, points out the sense in which the terms "dentistry" and "stomatology" were used in the Bulletin:

"'Oral health service', a general term that logically comprehends every aspect of *health service* relating to the mouth, was used as a synonym for dentistry and for stomatology, and also to include such border-line aspects as oral phases of maxillo-facial surgery" (8).

It logically follows, that the term "dentist" may be employed as a synonym for the term "stomatologist." But we find in the Bulletin, however, that the meaning of the term "dentist" is not the same as the meaning of the term "stomatologist." Apparently dentistry cannot be used as a synonym for stomatology. The distinction of the meaning of these terms will be observed when we compare the education of the dentist for the practice of stomatology (dentistry; Bulletin, p. 200) with the education of stomatologists for the practice of stomatology (dentistry):

"Such combined curricula in dentistry and medicine, founded on two years of pre-professional study in an academic college, are needed in several universities to improve particularly the foundations for *the practice* of *oral diagnosis* and *maxillo-facial surgery and to train consulting stomatologists*" (Bulletin, p. 200; italics not in original).

For the sake of brevity and clearness, we shall omit the terms "dentistry" and "dentist" from this discussion as inadequate and not all inclusive of the domain of present-day dental practice, and use instead when necessary the more correct terms, "stomatology" and "stomatologist."

The phrase "oral specialty of the practice of medicine" is equally ambiguous and is rather dangerously confusing to the whole educational question. Prof. Gies presupposes (according to conclusion

no. 6) that under the "dental-autonomous system" of educating dentists it is possible for "dentistry" to *become* an "oral specialty of the practice of medicine." It is proposed, according to Prof. Gies' plan, to:

> "Place dentistry, as an important division of health service, on a plane of intellectual, professional, and social equality with the accredited specialties of medical practice."
>
> "To make *dentistry as a whole*, in service for the patient, the full equivalent of an oral specialty of the practice of conventional medicine without basing it on the current requirements for an M. D. degree." (Italics not in original; 10.)

Dentistry, more correctly stomatology, can hardly be conceived to become educationally a specialty of medicine like ophthalmology, otology, rhinology, and other accredited specialties of medical practice, as long as its practitioners are trained under the dental-autonomous system.

That dentistry *may* in the *future* become an oral specialty of medicine under the dental-autonomous system and by following the *recommendations* of Prof. Gies, remains to be seen. This constitutes *the* dental educational problem. We do know that in the *past* ninety years it has not been able to place dentistry on a par with other accredited medical specialties. Stomatology, as we understand it, and the meaning assigned to this term in this discussion, *is* a specialty of medicine in the same sense as otology, rhinology, *etc.* Only in this sense could "oral health service" and "dentistry" be used as synonyms for "stomatology." But the terms "oral health service" and "dentistry" are not used in this sense in the Bulletin. It is *therefore* more correct to use the term "dental autonomy" as a synonym for "dentistry" and "oral health service." "Oral health service" thus becomes an antithetical term in meaning to "stomatology," and the terms must be considered as such in these deliberations.

The "health service" concept, introduced by Prof. Gies into his study, seems to me to have served no practical purpose. On the contrary it may have caused harm. Elsewhere, I called attention to the inadequacy of this concept as a guide to a solution of the *dental educational problem*. I also emphasized the need of taking a definite

stand on the choice of either one of the two educational systems (5), and to choose that system which promises to place dentistry on a par with other medical specialties. The matter becomes more complex and confusing, if "health service" is used as a synonym for the term "medicine." Suffice it here to point out, without discussing details, that the practice of dentistry can by no stretch of the imagination be placed alongside the *health service* group of practices of optometry, chiropody, nursing, etc., if we carefully analyze the nature of these practices, the training of these practitioners, and their relationship to medicine.

In this connection I may say that the Doctor of Optometry is not a doctor practising ophthalmology, and no amount of "graduate work" will alter the nature of the *practice* of the optometrist and transform it into a practice of ophthalmology (11). The stomatologist (dentist) on the other hand is a physician with a special field of medical and surgical practice:

"At the same time, I do not think we can do anything except regard dental education as a phase of medical education, just as I would say that a man who is a specialist in diseases of the eye, ear, throat, and nose, or the oculist, or the aurist, is practising a specified branch of medicine. I feel that you men are physicians with a specialty" (12).

There are no two ways about the matter: dentistry is or is not a specialty of medicine like other medical specialties. Stomatology, as we use the term, signifies dentistry as a specialty of medical practice.

(*c*) Who was the study prepared for? After a careful search I am as yet unable to say what particular social group it was written for except that "nearly 10,000 copies, without expense to the dental profession, have already been widely distributed to promote public interest in dental education and dentistry" (13). Apparently it was not intended for either dental practitioners or "general physicians." I am not altogether convinced that it served the purposes of educators in solving the *dental* educational *problem*. According to the view of the journal of organized medicine in America:

"In the past, dentistry has been too deeply absorbed in oral mechanics. The elaboration of dental practice into a health service that would be, in fact, a department of the healing art will involve *readjustments that should*

be made with a minimum of disturbance of the status quo." (Italics not in original; 14.)

From our viewpoint, it could hardly be considered a useful document of information for the lay public and prospective students of a "dental specialty of medical practice." Although:

"This *Bulletin* should be in the hands of all educators so that the youth contemplating the study of dentistry can be *guided to or discouraged from its further study.*" (Italics not in original; 15.)

Shall we say it might be of interest to prospective donors and philanthropists seeking to "endow" a worthy cause? A thorough and careful reading of the comment on the Bulletin by Dean Marcus L. Ward of the University of Michigan Dental School will be most suggestive on this and other points at issue (16).

The emphasis laid on "endowments" to "dental schools" for "*dental research* and "*dental* education," in the *dental* press after the appearance of the study, is both historically significant and valuable to the stomatologic movement. What does it mean to the power of the "vested interests?" At least, we find some light on this point in a statement by Dr. Albert L. Midgley, Secretary of the Dental Educational Council:

"With dentistry elevated to the educational standard of an oral specialty of medicine, yet a profession separate from it, proper mediums for more scientific advancement should be forthcoming in endowment form. When an equality between the two professional standards which Dr. Gies proposes can be achieved, *those who can endow will.*" (Italics not in the original; 17.)

Dr. C. N. Johnson, in an editorial, deplores the neglect, on the part of philanthropists, of dentistry's needs as compared with the large sums ($262,000,000 contributed to medical education and medical research from 1910 to 1926) obtained for the medical profession:

"If our wealthy men only knew just what dentistry has done for humanity, and what it is capable of doing in the future if favored with the proper facilities, there is no question that *endowments would come to it in abundant measure.* . . . With approximately 50,000 dentists serving the people of

America, it becomes essential to have a great deal of research, to the end that this service be dispensed along intelligent lines. Think of the added good that would come to our people if all of our dentists possessed more light on the one subject of the prevention of dental decay. . . . And if these problems are ever to be solved, it must be through the initiative of dentists themselves *favored by sufficient funds to carry out the work. Dental research must be conducted by dentists, for dentistry*, and to the ultimate end that the people are better served in a dental way." (Italics not in the original; 18.)

Prof. Gies directs our attention to this phase of dental education in the Bulletin (page 240):

"The dental schools in this country and in Canada, lacking endowments and in most cases being obliged to keep the quality of their work to the level of their income from fees, will be unable to proceed with the suggested improvements unless, individually, they receive large gifts of funds for the purpose."

Aside from all other considerations, the profession is indebted to Prof. Gies for having been instrumental in directing the attention of the parties concerned to give adequate financial support to make progress in dental education possible. We are assured by Prof. Gies:

"That endowments, in increasing number and total amount, will be given to the *most useful dental schools* from private and public sources seems certain." (Italics not in the original; 13.)

Who the study was prepared for I cannot say, and leave this question unanswered.

(*d*) The Bulletin has three points of indirect contact with the stomatologic movement in America. It is understood, of course, that the Bulletin in no way assumes a *dictatorial policy* toward dentistry (19). Its recommendations are advisory. The three points of contact are:

(*1*) The opposition of the "dental-autonomous theory of dental practice to the bio-medical theory of dental practice" (6).

(*2*) The "two-three-graduate" dental autonomous plan of education for dentists as opposed to the "four-two" stomatologic-medical plan of education for dentists (20).

(*3*) The economic advantages of the dental-autonomous system to the public as compared with the stomatologic system of education (21, 22).

(*1*) In substance, Prof. Gies supports the view that *now* dentistry should not be made a specialty of medicine although it should be recognized as one type of *health* service on a plane with optometry, chiropody, nursing, public health administration, etc. He defends the dental-autonomous theory on the basis of the *health service* concept, i.e., all health service is included in the extended meaning of the term *medicine*. Kirk and other leading autonomists similarly defend the dental-autonomous theory on biological grounds, i.e., that teeth are vital organs and that dental problems should be treated as *biological* problems and not necessarily as *medical* problems. From our viewpoint, all problems of health and disease pertaining to the oral cavity are by their very nature medical problems, in every sense of the term. Whether these problems belong to any one of the phases of stomatologic practice, i.e., oral *medicine*, oral *surgery*, or oral *reconstruction*, or whether emphasis is laid on curative or prophylactic practice, does not alter the situation. Oral health problems are biological and medical problems.

As stomatologists and students of history we are interested in a plausible explanation of *why* not now? Why should we wait one or more generations to make dentistry a specialty of medicine? Why not prepare *now* for the future of our specialty and the next generation of practitioners? If the present circumstances in the profession do not warrant a change in the right direction, *when will* the opportunity present itself? Changes are *now* proposed for the dental curriculum; why not make the right kind of changes now?

(*2*) Prof. Gies proposes the "two-three-graduate" plan. This provides for two years *pre-professional* training: three years *professional* training: and "optional" full year *graduate* curricula for all types of oral specialization. In addition, there are recommended collateral curricula:

"Combined dental and medical curricula, with or without graduate extensions, for dental and oral specializations on particularly broad medical foundations, especially for maxillo-facial surgeons, oral surgeons, orthodontists, and physicians learned in the principles of stomatology—phases of

practice that most intimately embrace the joint responsibilities of medical and dental service—all leading to appropriate degrees" (15).

This plan is based on the dental-autonomous thesis and proposes to keep dentistry a profession apart from medicine. The stomatologic plan recognizes the unity of healing and proposes a curriculum for future dentists along the lines of other practitioners of medical specializations, specialization in stomatology (dentistry) to cover a course of two years (23).

(*3*) Implied and expressed views in the professional and the lay press, that "dental-autonomous" education under the "two-three-graduate" plan has marked social and financial advantages for the public over other proposed plans (stomatologic ideas and plans have to date not only not been presented either to the professions or the public, but have virtually been boycotted and suppressed in the official dental press). A writer in the *New York Times* (July 3, 1927) called the attention of the public to the fact that "shorter courses" means "lower fees" to the public, and gave this economic argument as a reason for supporting the Bulletin's conclusions. Public opinion is thus directed in the wrong channel by these and similiar misleading and misrepresentative statements not borne out by a more careful analysis of the economic facts of *dental practice*. There has been considerable confusion about the "economics" of dental education based on an obsolete notion of the "economics" of dental practice. To some it might appear logical to adjust the quality of the dental curriculum on the basis of the fees practitioners charge their patients. The absurdity of this view of dental education becomes evident when led to its logical conclusion. The "poor boy" argument against higher standards for dental education appears, to me, to have received fair treatment in the Bulletin. This is a precedent that should faithfully be followed in future discussion. This is a most commendable progressive step on the part of Prof. Gies and his remark in this connection is certainly laudable:

"But Dr. Kells would apparently solve this 'large problem' by returning dental education to the conditions of 1878 and, consistently with his argument, by having dentists charge service fees to yield merely a 'fair return on the capital investment'" (8).

A careful reading of the general conclusions of the study (Bulletin, p. 239), especially number 5, will lead one to a rather sound question: If it be granted what is explicitly stated regarding "dental leadership," then (a) *how* and *why?;* (b) *when?;* (c) with what object in view was the study undertaken? I shall briefly outline several outstanding events that led to the inquiry into dental education. Familiarity with dental educational history and the history of our specialty since 1900 will be most helpful. Reference to these topics is made in the Bulletin (pp. 47–55 and 101–114). A thorough reading of the *Proceedings of the Dental Faculties Association of American Universities*, published in 1924, is indispensable in this connection (24).

The National Association of Dental Faculties was organized in 1884. The American Institute of Dental Teachers was organized in 1893. About 1900 (the year in which the "F. D. I." was organized in Paris), university dental schools holding membership in the National Association of Dental Faculties began to withdraw from this latter organization. Opposition to commercial influence of the *independent* schools (proprietary schools) brought about the unification of forces among the university dental schools, and in 1908 the Dental Faculties Association of American Universities came into existence. The schools represented were: California, Harvard, Iowa, Michigan, Minnesota, and Pennsylvania. The object of the organization was explicitly stated in the foreword to its *Proceedings* as published November 7, 1924 by the committee on minutes composed of Deans Alfred Owre (Minnesota), Eugene H. Smith (Harvard), and Charles R. Turner (Pennsylvania):

> "From its inception to its dissolution this body had as its chief aim the consummation of the ideal now so strongly set forth in the synopsis of this report, that is, raising dental education to the university plane with the ultimate aim of placing dentistry on a par with any other specialty in medicine."

The Dental Educational Council of America was organized in 1909.

> "From 1910 to 1921, the Council consisted of five delegates each from the National Association of Dental Examiners, the National Association of Dental Faculties, and the National Dental Association. The American Institute of Dental Teachers was not included because a large majority of

the faculties were assumed to be represented in the Council by the delegates from the National Association of Dental Faculties. The Dental Faculties Association of American Universities, ignored at first but later urged to accept representation, for a time declined to cooperate with the Council. During 1922 and 1923, however, three delegates from the Dental Faculties Association of American Universities were seated in the Council . . ." (B., p. 54).

Elsewhere (4) I pointed out the influence of the "D.F.A.A.U." on dental educational reform in America, since its organization and "how" it exerted its power on the Dental Educational Council to adopt higher standards for dental education. The fight for advanced educational reform between this organzation ("D.F.A.A.U.") and the commercially interested schools was intense. Dr. J. G. Sharp, President of the "D.F.A.A.U.," in his address in 1911, proposed that the Carnegie Foundation be invited to make an "impartial survey," a "disinterested survey" of dental schools. For ten years this organization endeavored to have an impartial study of dental education made and on May 7, 1921, according to Dean Smith's report at the fourteenth annual meeting of the "D.F.A.A.U." (held on January 22, 1922), Dr. Pritchett approved of the request of "D.F.A.A.U.," and agreed that a survey would be made.

It is in place to record that on five different occasions attempts were made to consolidate the "D.F.A.A.U." with the Dental Educational Council of America but without avail. (Attempts to consolidate the "D.F.A.A.U." with the other two educational organizations, the National Association of Dental Faculties and the American Institute of Dental Teachers, also failed.) The "D.F.A.A.U.," in spite of its advocacy of higher educational standards, its objection to commercialism in dental schools and its opposition to the Council, grew stronger and its membership increased. On October 11, 1922, Prof. Gies submitted a proposal to the "D.F.A.A.U." to consolidate with the other two American educational organizations (National Association of Dental Faculties and American Institute of Dental Teachers) and the Canadian Association of Dental Faculties and form a new organization, the American Association of Dental Schools (*Proceedings*, p. 114). The proposal was discussed at the fifteenth

annual meeting of "D.F.A.A.U.," January 19, 1923. Dean Smith of Harvard was "opposed to such an amalgamation."

Thus, in 1923, the influence of a most progressive vitalizing force in the dental educational world came to an end. The Dental Educational Council, under the influence of the proprietary and commercial régime in the dental schools, imbued with the doctrine of "dental autonomy" fostered and controlled by "vested interests," and dominated by a false pride of so-called professional independence, prejudices and ill-directed conservatism, has since been the only and official guide in dental educational policies. The historical value of these events in dental educational history is most significant to us. It points to the need of careful study of conditions before decisive steps are made. Did the developments follow the course Prof. Gies expected them to follow?

According to Dr. Henry S. Pritchett, President of the Foundation, the study was undertaken:

(1) To survey the field.

(2) To state the essential facts as they exist to-day.

(3) To seek to draw such conclusions as may be helpful to those who are concerned with medical and dental education in the United States and Canada.

"The present report is therefore an effort to do for dental education, as it now exists, the same service that the Foundation undertook to perform for medical education—to survey the field, to state the essential facts as they exist today, and to seek to draw such conclusions as may be helpful to those who are concerned with medical and dental education in the United States and the Dominion. It is to be borne in mind always that this is an educational report, not a technical study of either medicine or dentistry."

"The study has been carried out by Dr. Gies with an open mind and with the single desire to be of service to the cause of professional education. It has taken five years to complete the work. This has been due not only to the need to obtain exact facts, but also to the long and patient effort that Dr. Gies has made to *understand* the *situation* and to advise with the *dental profession*. No study of this character has ever been made in which there has been so complete cooperation on the part of the profession itself. The national associations of examiners, of practitioners, and of teachers, the national councils on dental education and the dental schools both in the United States and in Canada, have all lent them-

selves to this study in a sincere and patient effort to bring out a helpful and wise conclusion. The report is no less suggestive and interesting to practitioners and teachers of medicine than to those of dentistry." (Italics not in the original.)

While it is not intended here to discuss some of the statements made by Dr. Pritchett in his preface, we should, nevertheless, not overlook the fact that it had to take Prof. Gies considerable time "to understand the situation" and to advise with the "dental profession," besides the time that has taken him to obtain "exact facts." The study was an effort to do for dental education, "as it now exists," what the Foundation did for medical education.

We are now led to our next inquiry: to what extent were the objectives of the survey carried out? To answer this question we must turn to recorded facts pertaining to this question. Let us examine the available data and see to what extent the three objectives have been fulfilled in the study.

(A) An examination of the contents of the Bulletin will show that nearly every topic has been covered with the exception of a few important omissions.

a. We note, for instance, reference made to the Federation Dentaire Internationale ("F.D.I.") an *international* organization of dental-autonomists (p. 5) but no mention is made of the Association Stomatologique Internationale ("A.S.I.") an *international* organization of stomatologists who since 1907 have championed the cause of dentistry as a specialty of medicine.

b. Reference is made to the newly established American Association of Dental Schools in 1923 (p. 4), but we are not made familiar with all the facts that led to its creation, except that:

"During the summer and fall of 1922 there arose, among the dental schools in the United States and Canada, a general desire for unification of efforts to advance dental education" (B., p. 52).

c. Of the Dental Faculties Association of American Universities, we know that it opposed the Dental Educational Council of America chiefly on the ground that:

". . . The Council, containing some influential beneficiaries of commercialism in dentistry or sympathizers with it, did not respect essential needs

of dental education. . . . The Association disregarded the circumstance that the Council's endeavors to improve dental education were gravely handicapped by the prevailing separation of the schools into two opposing groups" (B., p. 105).

d. Of the tendencies in the United States to make dentistry a specialty of medicine, from the standpoint of organized medical groups, dental groups, or combined medical and dental groups, we read little. With regard to the efforts of a dental group in the American Medical Association, we learn that:

"The Section on Stomatology of the American Medical Association, established in 1881 to make the relationship between medicine and dentistry more intimate, was disbanded in May, 1925, chiefly because of lack of medical interest in dentistry" (B., p. 5).

We find no record of the part "dental politics" and other factors played in the closing of this section.

e. The reader of the Bulletin can hardly form a conception of the underlying causes, the condition in the American dental profession, that gave rise to the stomatologic movement in America in 1923. Neither is one in a position to learn much of the distinguishing characteristics of the stomatologic movement in America (25) from that of Europe (26) and from the attempts, in previous years, to advance the idea of the need of a "medical degree" for the better class of dental practitioners (27). Some space is devoted to the presentation of the classical arguments against making dentistry a specialty of medicine (B., pp. 10–14).

But a movement is not to be confused with a society, although movements find their expression through the medium of "organized" groups. If we look, for instance, to the "History of dentistry" (28) in Belgium and the "History of stomatology" (29) in Belgium, we will get a very clear historical perspective of the distinction. The instance of the efforts of Dr. Quinet in the stomatologic movement in Belgium is but a typical illustration of what is now taking place in the United States. Ample data will be found in the development of the stomatologic movement and stomatologic societies in Italy, France (30) Hungary, Russia, Poland, Czecho-slovakia, and other countries (31, 32), to point out the distinction.

Reference to the organized attempt by dentists and physicians in 1924 to make dentistry a specialty of medicine is dealt with as follows:

"The American Stomatological Association, founded in October 1924, aims to convert dentistry into a specialty of the practice of conventional medicine, but does not appear to be receiving any marked encouragement from either dentistry or medicine" (B., p. 5).

Having been the founder of that Association, and having followed closely the development of the stomatologic movement in America since 1923, to-date, it is difficult for me to understand how it can be said that the movement received no support from either medicine or dentistry when we find among those connected with these activities such representative men as Drs. Billings, Rosenow, Mayo, Osborne, Bassler, Mackenzie, Bloodgood, Bayley, Satterlee, Cornwall, Holmes C. Jackson, E. V. McCollum, Norman, Wyeth, Ottofy, Sarrazin, Cross, Thoma, Briggs, Angle, Hocking, Murphy, Fahy, and many others.

These are only a few illustrations of interest to stomatologists. These omissions, perhaps unimportant in themselves, have, nevertheless, a great bearing on the historical analysis of Bulletin No. 19 in relation to the stomatologic movement.

(B) The second objective of the study may be subject to various interpretations. We cannot possibly set out to merely gather facts without a perspective or plan. Some facts may be relevant to a given objective in a survey while irrelevant in another connection. If it were a matter of merely obtaining "exact facts" we might say that these are adequately covered in Part VI—Dental Schools in the United States and Canada (pages 245–617), and Part VII—Appendix (pages 621–665). Excepting the preface by Dr. Pritchett, and the introduction by Prof. Gies, and Part V—General views and conclusions (pages 225–241), the first four chapters might have been omitted altogether. The meaning attached to "facts" is apparently wider in application, and appears to me to refer to a broad and more general description of the *situation in dentistry* as Prof. Gies understood it. Let us see how we may understand "dental education," in terms of the "facts as they exist today," by comparing it with the objectives of a study carried out in "medical education." In the Preliminary

Report of 1927 of the Commission on Medical Education, we note the following significant statement:

"Medical education concerns itself primarily with the qualifications and preparation of students to practice medicine. . . . The training should be sufficiently broad and sound to serve as the groundwork for subsequent preparation for those who desire to go into one of the specialties of medical practice, into research in one of the sciences or in some branch of clinical medicine, into public health work, into medical teaching or into some field allied to medicine. This conception of the basic course presupposes an understanding on the part of medical educators of the problems of medical practice. It is true that many of the requirements of the medical curriculum and of medical licensure have been worked out by individuals familiar with these problems, but some of the features that are now modifying medical practice have not been reflected in medical teaching. The medical profession, broadly speaking, has a responsibility not only for the adequate preparation of individuals to begin the practice of medicine, but in a larger sense to keep the entire profession familiarized with and competent to use the best methods of diagnosis, treatment, and prevention of disease" (33).

It is interesting to observe that considerable time has been devoted by this Commission to finding out the "needs of medical practice" to serve as a guide to "medical education." The needs of the medical practitioner has thus been made a special point of consideration in medical educational *problems*.

The Gies study has, apparently, not dealt with the facts of dental practice, of the economic and professional needs, of the rank and file of practitioners of today. The facts of dental practice, which include the economics of dental practice, are undoubtedly "essential" to a solution of the dental educational problem. In this sense, it can hardly be said that the Bulletin deals with the essential facts as they exist today. It may more appropriately be considered a survey of dental schools, their classification according to varying standards, buildings, personnel, equipment, administration, examination of students, problems of curriculum, teaching and the present status of dentistry, from the viewpoint of pre-professional and professional school preparation. It cannot be said to have dealt with the *broad dental educational problem*, in the sense in which medical educational problems are approached. The economic problems of dental practice have natu-

rally received no attention. Neither have the "needs" of dental practitioners received due consideration. The statement in the study regarding consultation with the "dental profession" must not be misconstrued but should be correctly understood to refer to the "leadership" of the dental profession (representatives of the American Dental Association, Dental Educational Council, dental schools and related bodies). Prof. Gies gives an account of the splendid coöperation offered him as director of the study by fully 400 dental teachers and many officers of dental organizations in his "acknowledgments" (page 241).

From the historical side, we are concerned in finding a description of the general situation in the dental profession in 1921 when the study was begun. Dean Marcus L. Ward of the University of Michigan Dental School throws some very interesting light on this point:

"Those who are at all familiar with dental education in most foreign countries know that the principal fundamental difference between dental education in those countries and in the United States is that it is a part of medical education in the foreign countries and an independent profession in the United States. Since students of practically all branches of science, literature and of the arts, have been going to foreign countries to finish their education for many years, it is, until one understands the situation, a logical question for a president or other officers of a university to ask why dentistry should not be a part of medicine in this country as it is abroad. . . . Those in control of better educational institutions of this country have given this question serious consideration for many years and have not been able to reach a decision largely because the dentists have been unable to convince such authorities that dentistry in the United States has developed in its health service aspects beyond what it is in most foreign countries because it is an independent profession in the United States. It is not strange to have a profession develop further when independent than when subordinated to other specialties, but dentists generally have not been able to convince the educational authorities of this country that dentistry should *always* be conducted as an independent profession. Whenever educational authorities are confronted with requests for appropriations for duplicate departments for medical and for dental schools for the fundamental subjects, they are compelled to ask why there should be separate departments for these fundamental subjects and to urge an answer to the question as to

whether dental education in foreign countries is not more efficient and economical than in the United States" (16).

The activities of the "D.F.A.A.U." had brought the question of *status*, as it concerned the profession *educationally*, to the foreground. The advances in medical science, the increasing influence of the preventive movement in the healing art, especially the newer interpretation of oral sepsis in terms of the principle of focal infection, added to the imperative need of founding dental procedures on a more scientific basis. The cry for "medical and dental coöperation," a makeshift fundamentally as regards a solution of scientific dental problems, became the hope of the day. It is most interesting to record the attitude of our leading journal (34), representing dental-autonomy in America, toward the question of status in 1921:

"For several decades, in fact, almost from the beginning of dentistry as a specialty of medicine dentists have endeavored to obtain proper recognition from the medical profession, but without avail, except in a few isolated cases. . . . The medical profession since the very origin of dentistry as a separate specialty has consistently assumed an attitude of aloofness toward dentistry and has consistently refused to recognize dentistry as an important adjunct to the healing art. . . . It seems that this recognition for which we have clamored for years is gradually coming, as medical men generally are in a more receptive attitude toward receiving the advice of dentists" (34).

The dental profession was thus face to face with the ever present critical situation of status: Shall our practice become a specialty of medicine or shall we continue as a profession independent of medicine?

It is hardly possible to fully understand the situation in the profession when the "facts" are searched for only in dental schools. The facts of dental practice were apparently not considered in the Carnegie deliberations, neither did the various problems of the rank and file of the dental profession receive due attention. Recognizing as we stomatologists do, that problems of dental practice and dental education are closely interrelated, we can more readily appreciate the inadequacy of the Gies study as a guide to the solution of the dental educational problem.

(C) Inasmuch as the "general conclusions" in the Bulletin are not

always correctly recorded in dental literature, I deem it necessary to refer to the eight conclusions as they appear in the Bulletin (pages 239–240). To the historian it is quite important to ascertain whether these "conclusions" were arrived at as a result of the facts gathered. We know from records available that the main conclusions, in principle, were presented before the issuance of the Bulletin in 1927. In 1924, Prof. Gies presented his views in the following general statement:

"I stated that my paper was intended to direct attention to general principles and that my views rested on the broad conclusions: a) that dentistry is and may suitably remain an independent division of health service; b) that it should be made equivalent in serviceability to an oral specialty of medicine; and c) that it should be improved accordingly. I felt that the suggested improvements should be tested voluntarily, if at all, by the schools best qualified to do so" (35).

Attention was given to the main "conclusions" in 1924, but there was also considerable confusion about the objective of the conclusions as regards the future of our specialty. Dr. N. G. Thomas, in an editorial comment, even alluded to the possible implication of the creation of the "stomatologist":

"The development of the stomatologist of the Gies plan calls for the dental mechanic. The optician and lens-maker or the pediatrician and the appliance manufacturer are used to illustrate the relationship. The stomatologist examines the mouth, makes all intraoral preparation and inserts intraorally the thing prepared. To this mention the answer is made that the mechanic is here; the intraoral worker is here; the relationship has been here a long time. What does it imply?" (36).

In view of the recent uncalled for attack on Prof. Gies, the following editorial comment in the *Dental Cosmos*, for April 1924, is most striking:

"Two striking situations have resulted from this rapid accretion of data within that section of the art and science of healing to which collectively we are accustomed to apply the term dentistry. First, the designation dentistry has ceased to correctly define the field of its activities and, second, the curriculum of our specialized educational institutions has become inadequate, both as to scope and content, as a preparation for more than

a fraction of dental practice. . . . In a paper by Dr. William Gies, recently read before a meeting of the American Association of Dental Schools held in Chicago, there is set forth what is doubtless a forecast of the conclusions and a suggestion as to its policy regarding dental education that will be formally embodied in the final report of the Survey Committee. . . . The foregoing quotations clearly indicate the pedagogical soundness of the principle which they involve, *viz.*, the adaptation of the educational system to its objective purpose which is the making of dentists. . . . After a most careful study of the report we find ourselves in hearty agreement with its various suggestions as being in entire accord with principles that we have long advocated in these pages. Doubtless opposition to the general plan of reorganization as proposed will arise in various directions, but such opposition is most likely to voice the sentiments of those more interested in the financial than in the cultural phase of dental education. We shall await the outcome with interest" (37).

From what has just been stated *three* questions may be raised as regards the "conclusions."

(1) Do the "conclusions" in the Bulletin differ fundamentally from, or are they in agreement with the educational program of the "vested interests?" (38).[5] In November 1924 and in May 1925 the Dental Educational Council, dominated and controlled by a majority of dental autonomists, endorsed the "two-three graduate" plan (39).

(2) From the "facts" (concerning dental schools) presented in the study, inadequate and incomplete though they are, could we draw the opposite and contrary conclusions? (considered in terms of opposite and contrary theories of dental education, i.e., stomatology versus dental autonomy). The answer is in the affirmative. There is nothing definite in the "facts" which would indicate that the dental curriculum may *not* be advantageously adjusted to comply with the requirements of the stomatologic educational program. Again, I must call your attention to the article by Dean Ward, repeatedly referred to in this discussion, for confirmation of my statement. From the implications in Dr. Ward's paper, one might be led to infer that Prof. Gies might have drawn conclusions favoring the establishment of dentistry as a specialty of medicine.

[5] A discussion of the "vested interests hypothesis," presented before the New York Society of Stomatology in January 22, 1929, was published, in abstract form, in the June issue (1929) of the *Dental Outlook*.

(3) Do the conclusions and recommendations conclusively warrant that the deplorable conditions in dentistry, which were responsible for the inauguration of this study, will be remedied by the introduction of Prof. Gies' proposed reform dental curriculum (the "two-three-graduate" plan)? The answer is in the negative. In spite of the *flexibility* of the plan, the philosophy of the plan precludes any possibility of ever establishing dentistry as a specialty of medicine on the same educational level with other accredited medical specialties.

The "two" part of the plan is a move in the right direction. If nothing else were accomplished, except the institution of the requirement of two years of *pre-professional* academic training for dental students, the efforts of Prof. Gies must be recognized as an achievement and a positive contribution to dental education.

A reading of reliable and authentic literature pertaining to the stomatologic movement in America will point to the reasons why the "2–3-graduate" plan is an anti-stomatologic plan. In his synopsis of the "two-three-graduate" plan, Prof. Gies gives us also his own version of the "chief functions" (10, p. 446) and the "main elements in the philosophy" (10, p. 449) of the plan. As to its philosophy, it aims at the:

> "Recognition of the fact that dentistry is a division of health service, and of the need, in the *public interest* for the continued progressive development of dentistry as a *separately organized profession*. . . . Acceptance by dentistry not only of enlarging professional responsibility in health service, in all aspects of its practice, but also of the condition that *service equality with an oral specialty of medicine* is attainable through equivalence in intrinsic educational and professional merit, *not by aping identity*." (Italics not in the original; 10, p. 449.)

"The prospective achievements" of the proposed curriculum in the Bulletin are, among other things, to "*help to maintain the dignified separate organization of dentistry*" (10, p. 450).

Prof. Gies introduces the "graduate" element as an essential part of his reform, the "two-three-graduate" plan, and emphasizes its importance, in his discussions of Dean Milberry's criticism, and its distinction. He distinguishes it also from the "two-three" plan:

"The two-three-graduate plan *could not accomplish the suggested improvement of dental education,* if it were operated as a "two-three" plan without a graduate phase. The same is true of the two-four plan." (Italics not in the original; 10, p. 453.)

We are also informed, in the same discussion, that in practice the two-three-graduate plan becomes two-four, two-five, and two-six plans:

"Its primary phases can be adopted separately, experimentally, and gradually, *without impairment of the system* into which they may be fitted. . . . The optional graduate phase provides in effect, by addition, *two-four, two-five, and two-six plans* culminating in all aspects of oral specialization and research." ("Without impairment of the system" not italicized in the original; 10, p. 454.)

What plan, then, is it? If the years of dental training are increased to as many as eight years, why not train the prospective practitioner under the 4–2 stomatologic plan and qualify him as an honest-to-goodness practitioner of a division of medical practice? If we eliminate the "graduate" aspect of the plan, we have a "two-three" plan which makes it impossible for dentistry to become an "oral specialty of the practice of medicine." If we retain the "graduate" phase of the plan, then let us ask the straight-forward question; who is the dentist, the product of this reform curriculum? What is his function *in practice,* in his service to his patients? In a former discussion (23) I pointed out that he is a "phantom" or an "inlaydontist" which is about the same. His "professional qualification" will make him, to repeat a phrase expressed by the stomatologist, Dr. Breitbach of Dresden, in 1907, "neither fish, flesh, nor fowl."

From the brief analysis of certain phases of the study, how shall we evaluate it historically as it relates to our movement? Let us bear in mind the conception of *historical* values and see how the question of "dentistry a specialty of medicine" is answered. The following issues arise: (1) Is the issue *settled?* (2) If so, is it satisfactorily settled to *all* parties concerned? To get a reliable answer to these two questions we must turn to available records dealing with events (a) *prior,* (b) *during,* and (c) *after* the periods the survey was in progress.

(a) Briefly stated, there are ample data to show that *before* 1921 dental and medical opinion registered its approval of "dentistry as a specialty of medicine" (40). (b) No less is the evidence, to support the claim for "dentistry a specialty of medicine" *during* the period of the study (1921–1927). The remarks in the presidential address by Dean Alfred Owre, of the "D.F.A.A.U." on January 19, 1923, should ever so often be repeated:

"As you are all aware, our original status was that of a specialty in medicine. We are now, I believe, on the road back to the parental rooftree. Educators and scientific thinkers in every quarter are challenging our rights to practice our vital calling without the biological training required of specialists in other regions of the body. The best scientific thought is agreed that dentistry is a field of medicine." (*"D.F.A.A.U." Proceedings*, p. 109.)

(c) Since the issuance of the Bulletin (1927) conditions have been more favorable toward the establishment of dentistry as a specialty of medicine than ever before. Dr. Owre's comment on the study (before its general distribution) before the section on dental education of the Seventh International Dental Congress ("F.D.I.") in 1926 held in Philadelphia is indeed illuminating. Dr. Owre expresses his view thus unequivocally:

"And I am not forgetting that higher goal of dentistry toward which I have been laboring for twenty years, the ultimate placing of dentistry on a par with recognized specialties in medicine. . . . I have had no reason since to change this view. I only rejoice, with many others who held it, that it has begun to seem possible" (41).

The stomatologic movement, since 1927, has been under the leadership of stomatologists engaged in the *practice* of the specialty of stomatology (dentistry), and supported by general physicians and other specialists in medical practice. The American Society of Stomatologists, even though a "minority group" in the American Dental Association,[6] marches on toward the realization of our profes-

[6] Only dentists who are members in good standing in the American Dental Association are eligible to membership in the American Society of Stomatologists. The same applies to physicians, i.e., those who are members in good standing in the American Medical Association are admitted to membership in the "A. S. S."

sional ideals through the efforts of such representative practitioners as Ottofy, Perry, Sarrazin, Baker, Woolgar, Quinby, Hlavac, Aruti, Wardner, Adams, Rasmussen, and others. On October 8, 1927, the Society adopted the following declaration of principles:

"*Declaration of principles of the American Society of Stomatologists. Adopted by the Organization Committee, October 8th, 1927, in conformity with the International Stomatological Association (A. S. I.)*"

"(1) Stomatology, which includes odontology (dentistry), is that branch of medical science that is devoted to the study and treatment, both medical and surgical, of the mouth in health and in disease.

"(2) We believe in a single standard of medical education for all who practice the healing art in any of its branches.

"(3) We believe that the medical school curriculum should include a course in stomatology, which should embrace oral pathology and diagnosis of oral lesions, and should be equal in quality to other medical specialties taught. By such instruction every graduate in medicine will acquire a knowledge of normal and abnormal conditions of the mouth, and hence will be able to prevent as well as assist in the cure of pathologic conditions in this region.

"(4) We believe that the advanced status of medico-dental science and the interest of public welfare no longer warrant the continued separation of the two professions, and that the merger of dentistry and medicine into one profession will be brought about most effectively by readjustment of the undergraduate and graduate medical curricula in such a manner that only those who have received special training, of a recognized standard, in a given specialty shall be entitled to the designation of 'specialist.'

"(5) We further believe that the protection of health demands that the public be educated to appreciate the necessity for cooperation with stomatologists (dentists) and physicians, (as very many diseases begin with infection in some part of the mouth) to prevent illness and to preserve health."

The issue may appear settled to the "vested interests." The view of Dr. Kirk, the editor of the *Dental Cosmos*, was shared by the late Dr. Truman W. Brophy, President of the "F.D.I.," who publicly endorsed in his address before the Seventh International Dental Congress held in Philadelphia, August 22–27, 1926, the autonomous educational program:

"The subject foremost in the minds of the profession today is that of dental education. The question of requiring students of dentistry to take

full courses in medicine before entering upon their dental studies is now discussed infrequently, and I believe the matter *has been definitely and finally settled*". (Italics not in the original; 42).

It was settled in 1907 (the year when a break in the "F.D.I." ranks took place, when the "stomatologist" members formed a new organization, the "A.S.I.," to further the cause of stomatology) when the "F.D.I." adopted *definitely* the dental-autonomous educational program (43). But it must not be understood that *all* educators, even under the present dental-autonomous régime, are supporters of the dental-autonomous educational program. Some are opposed to it. Some are not decided about it. (*a*) Dr. Ralph R. Byrnes, Dean of the Atlanta-Southern Dental College, in discussing dental education in the United States, is of the opinion that:

"The future of dentistry depends entirely upon dental education of the future. It is my opinion that the dental curriculum in the future will approach more closely the medical curriculum. Dentistry cannot be divorced from medicine, for it is as much a specialty of medicine as dermatology, or otorhinolaryngology are. . . . Reams could be written upon the question of whether dentistry should be made a branch of medicine, but to my mind, the answer to the following simple question will bring the solution, namely: Has dentistry, as an independent branch of health service, met all its obligations? If it has, there is no need for radical revision in the teaching methods of dentistry or for the affiliation with medical schools. If it has not, and if closer cooperation between the medical and dental professions can be assured by merging the two, then such action will be justified. The answer remains to be written" (44).

(*b*) The committee of the Faculty of the School of Dental and Oral Surgery, Columbia University, in its Report on the Bulletin, issued February 16, 1928, deals briefly with the "facts," the "debatable parts" and the "recommendations" as well as other topics. The committee's opinion included this comment:

"To what extent the recommendations of the report are sound in practice can be seen only in the long run; time will show" (45).

In his preface, Dr. Pritchett indicates how far the study approached the *solution* of the dental educational problem. He emphasizes the

need of "recognition" of our specialty. In addition to other valuable suggestions, he expresses the view that:

> "The practice of dentistry cannot *now* be made a specialty of the conventional practice of medicine, but should remain a health service of *equal recognition* with other specialties of medicine." (Italics not in original; B., p. xvi.)

To some it may appear that, historically, we have been going around in a circle. To others, it might even seem that we are today as far from our ultimate objective as we were in 1921, before the study was begun. Factually this may be true, for we note today that not many are adherents of the stomatologic view, whatever the reasons for this situation may be. We are still a "minority" in organized dentistry. Historically, however, this is not the case, as I shall later indicate. We have progressed and in a sense this progress may be attributed to the survey in the dental schools during 1921–1927.

With regard to the stomatologic movement, the event under discussion has a decided practical significance for us. If compared with a similiar survey in France in 1925, and the developments in dental educational history in Germany, England, and other countries, we shall more readily be in a position to determine the "historical value" of the study. We may now make the following three observations:

First. The conflict between stomatologists and dental autonomists in America is not to be considered a conflict merely between individuals or "groups," but should be interpreted as an *expression* of a conflict between them representing two opposing and antithetical doctrines.

Second. The forces, designated as "vested interests," which resist progressive tendencies in the dental profession, especially those tendencies which aim to make dentistry a specialty of medicine, must not be overlooked in an historical evaluation of the conflict between stomatology and dental autonomy.

Third. The beginning of the stomatologic era in the educational history of our specialty in America. Inasmuch as this is an unfamiliar subject it calls for elucidation. If we visualize the development of institutional dental education in the United States for the past ninety years as having followed a unilinear course from 1839 to 1929, we will note three marked periods of internal readjustment

(46). While fixed dates separating these periods are unimportant here, provisionally we may speak of the *proprietary period* to have continued up to 1907. From this time up to 1923, we may speak of the *university period*, during which the university ideal in dental education was advanced, and at the same time opposed by the "vested interests" in power during the proprietary era. The university ideal in dental education made itself thus felt. In 1924 we note the following important suggestion advanced in the Nineteenth Annual Report of the Carnegie Foundation:

"Discontinuance of all independent dental schools, . . . unless they should be sufficiently endowed, suitably affiliated, and properly equipped to promote satisfactorily the teaching of modern dentistry, which cannot now be claimed for them" (47).

In 1925, the end of the proprietary régime in dental schools was announced in the Twentieth Annual Report of the Carnegie Foundation:

"Commercial influences long controlled the progress of dental education. In recent years the conversion of independent dental schools into integral parts of universities, including several affiliations that are steps toward organic union, has been one of the most striking as well as beneficent developments in dentistry" (48).

From the historical point of view, when we *now* look back at the past, we may interpret the efforts of the "D.F.A.A.U." as not altogether wasted. And with the same historical perspective, we may evaluate Prof. Gies' efforts, in *unifying* the schools, to have contributed to a progressive outcome.

In my opinion, Prof. Gies' efforts have materially aided in bringing to a close the university period in dental educational history, which thus paved the way for the *stomatologic period*. With the university ideal in dental education triumphant, the *stomatologic ideal* rose next on the horizon of university dental education. Here again the emphasis is shifted. The stomatologic ideal in university dental education is opposed by the "vested interests" now in control of our educational system. Evidences of this opposition, which have not always been open and above board, are not lacking. It is taking on

the usual form characteristic of the methods employed in all such struggles between the old and the new order of things. Dean Banzhaf of Marquette University Dental School registered his protest against the stomatologic movement, apparently due to a misapprehension and misunderstanding, in the following terms:

"I am glad to be able to report an almost unanimous opposition to the movement started by a small minority of our profession to create a new profession, not included in or identical with either conventional medicine or dentistry; namely, stomatology, which, it is their desire, will eventually take over certain of the functions of dentistry as we now understand them" (49).

What stomatology is and what it is not, has been presented to interested readers (50).

To form an unbiased judgment and a fair estimate of the study, in the light of the "vested interests hypothesis," we will do well to bring to our aid the writings of Prof. F. C. Waite of Western Reserve University, a man with great sympathy for and understanding of dental situations. His participation in medical and dental educational activities makes his views invaluable to us:

" . . . As early as 1910 some dental educators advocated a survey of dental education by some agency outside of dentistry in order that a judicial rather than a biased view might be attained. . . . The two divergent views as to whether such a survey should be made by a dental agency or by a nondental agency were happily compromised by a cooperative survey" (51).

The Carnegie Foundation and the Dental Educational Council were thus coöperatively engaged in carrying on the survey.

Psychological (social) and cultural (economic) forces of dental-autonomy are so subtly at work in the dental profession that even an astute mind like that of Prof. Gies was unable to detect and to resist their influence, which colored the data and logically the "conclusions" of his study. His unfamiliarity with the actual practices of dentistry, as carried on by the rank and file of the dental profession, may have been another handicap in fully understanding the dental educational problem as it affects us. Nor do I see how Prof. Gies could have arrived at satisfactory conclusions from the data made available to

him, especially when we realize that he has not been afforded an opportunity to learn of the *needs* of dental practice and dental practitioners.

Recently attacks on the Bulletin appeared in certain dental journals, notably the *Dental Cosmos*. It is apparent that the editors are surely unwarranted in attacking, on the grounds they did, the splendid effort on the part of Prof. Gies and the Carnegie Foundation to solve the problems of dental education. It is certainly naïve on the part of an influential dental journal to attack Prof. Gies, with whose general principles of dental education they declared themselves in agreement, and whose "pedagogical soundness" was acknowledged, on the ground of his being a *layman*. It will unquestionably be conceded, by those qualified, that *dental* education is a division of general education just as dental practice is a division of general medical practice. Dental education has an *educational* side as well as a *dental practice* side.

In estimating the historical value of Prof. Gies' outstanding work, we must constantly bear in mind that the dental educational problem, in its broad sense, is an international problem, if we recognize that science has no geographical boundaries, and by no means a simple one (52, 53, 54).

SUMMARY

To evaluate the study, it is not sufficient to express satisfaction or dissatisfaction with it. Such judgments are not necessarily healthy judgments, for they are motivated by subjective factors more than by an historical insight. One must, therefore, take account of more than the immediate and directly related events to estimate the "historical value" of the study. As an illustration of the need of a broad historical outlook on these questions, I may point out the "D.F.A.A.U." episode to which I called your attention elsewhere in this discussion. What may have been considered a false move at the time (in 1923–24) has apparently proved to be (in 1929), in my estimation at least, a most important and progressive step in our educational development.

In this brief comment on the study a number of important issues had to be left untouched, for this discussion was not intended to be an exhaustive analysis of the vast field covered in the Bulletin. My

major object was to present a *method* of approach to the study, by which method I hope others will be able to guide themselves in future discussions. In these discussions, I consider it essential to take cognizance of several fundamental ideas in order to assign the study the commanding place it deserves in the history of the stomatologic movement in America.

The science of stomatology (dentistry) must be differentiated from what has generally been termed "dental science." The object of the science of stomatology is essentially to serve as a foundation for its application to the methods of prevention as well as curing oral disease. It has thus fundamentally a utilitarian objective. But there are certain phases of investigation pertaining to stomatology which must be pursued quite independently of application and immediate usefulness. Methods of investigation of the nature of disease (oral disease), employed in the broad field of medicine, should evidently not be excluded from our equipment of research and practice. It is also well to bear in mind that the laboratory method is not the only avenue of approach to a study of stomatologic problems. Accumulated experience from practice, the empirical method, furnishes us with valuable and indispensable information. To derive the full benefit from the scientific method in the study of oral health and disease, laboratory investigation should be synchronized with the scientific data obtained from clinical research. The stomatologist (dentist) of today who is essentially a clinician (practitioner) approaches his problems through the gateway of science. If there is no science of stomatology, one must be created. But one mode of therapy—*reconstructive therapy* (often confused with bridges, crowns, fillings, etc.)—can never serve as a foundation on which to build the science of stomatology. Oral reconstruction can no longer be designated as *the* outstanding characteristic of that which in some quarters has been accepted as "dental." Dental practice calls for more freedom in the science of stomatology. Scientific freedom, in the sense here indicated, may most easily be obtained through the presence of such a spirit among teachers and practitioners. Dental education should be the embodiment of this spirit. Dental education has so far not been motivated in its activities by this ideal.

The needs of dental practice adjustable to the needs of the public

and the public health are not reflected in the dental curriculum. The dental curriculum has not been adjusted to the ultimate needs of clinical stomatology. Such deficiencies are compensated by a small minority of practitioners through unsystematized after-training in fundamentals and special subjects. The theory of dental education, based on the "autonomous" view of dental practice, is not guided nor modified by the progressive tendencies and the modifications of dental practice in accord with the bio-medical theory.

We are led to deduce, from an analysis of the study, further evidence of the broad applicability of the "vested interests hypothesis" in dental education. It further establishes the fact that the dental-autonomous educational system permits of no "evolution" of the present mode of dental practice, as an independent form of health service, to that of a health service of an "oral specialty of the practice of medicine." The dental autonomous doctrine is inherently antithetical to the stomatologic doctrine. Stomatology (dentistry) is a *branch of medical practice today*, and it should be made so in *every respect* in the future.

The dental educational *problem* is so big and broad in its scientific, educational, and socio-economic aspects, that it deserves a thorough investigation representative of all interests concerned. On an earlier occasion, I proposed to Dr. Kirk and Prof. Gies that such a survey be inaugurated, to represent stomatologists, dental autonomists, dental and medical schools, and to include the public. Dr. Perry again proposed such a survey in his 1928 report (55).

Prof. Gies' study lends further convinction to the belief that the stomatologic movement in America must continue under the leadership of practising stomatologists, organized *independently* of all other existing professional societies, but in coöperation with them to further its objectives. The American Society of Stomatologists must continue to champion, uncompromisingly, the cause of "dentistry a specialty of medicine" in every respect, and must under no circumstances surrender any of its rights and privileges bestowed upon it by virtue of its position as a defender of the welfare of the rank and file of the dental profession.[7]

[7] The American Society of Stomatologists is of the view that dental practitioners are entitled to consider themselves as being engaged in the practice of a *profession which is*

Education is a field probably as complex as that of *history*. In their application to our specialty what is true of one is probably true of the other. In reading the Bulletin, and before judgment is passed, let us recall the words of Prof. Karl Sudhoff:

"The medal indeed, has its reverse side. The historian of general medicine is, on his part, in no sense competent to give intelligent and exhaustive instruction in the histories of the several specialties, if he relies upon his fund of general knowledge alone. That requires first and foremost, a thoroughgoing course of self-instruction, such as could only be obtained in connection with long continued practice of the specialty itself. Only an ophthalmologist could write a history of his specialty that would be really worthy of the name. Only a surgeon could write a history of surgery that could be taken seriously. A suggestive and stimulating history of a disease can only be written by a practitioner who is thoroughly familiar with the manifestations at the bedside, and so on" (56).

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PRELIMINARY COMMENT ON SOME STATEMENTS IN DR. ASGIS' REPORT ON THE CARNEGIE FOUNDATION'S STUDY OF DENTAL EDUCATION

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Discussion of portions of Dr. Asgis' report[1] will be reserved for a future issue, but the following corrections and explanations should be noted in the number of this *Journal* containing his comment.

(1) Dr. Asgis presents two quotations showing that I have used "stomatology" and "dentistry" synonymously. But from an indirect reference that he also quotes, and from which he does not draw all the obvious implications, he assumes that the two terms were not used as synonyms in the Bulletin on Dental Education. In the index, at the bottom of page 689, this entry may be found: "Stomatologists. *See* Dental practitioners, Dentists." At the top of page 690 is the following: "Stomatology: synonym of dentistry; no need for replacement of term 'dentistry,' 5, 11, 13, 134, 135, 210, 239, 616, 617." The index was prepared by me.

(2) Some of Dr. Asgis' difficulties with the term "health service," as used in the Bulletin, would not have arisen if the following explanation, stated with the general conclusions, had been noted in detail (p. 239):

> "Throughout this Bulletin 'health service' is used in its natural sense to signify any and all private and public means to maintain or to promote health, to prevent disease, to restore health by treatment and cure of sickness, and to alleviate the discomfort, distress, and disability of incurable ill-health. *Public-health administration, education for the prevention of disease, medicine, dentistry, nursing, and pharmacy are important divisions of health service.*" (Italic not in the original.)

[1] Asgis: "The historical significance of Professor Gies' 1927 study in the stomatologic movement." *Journal of Dental Research*, 1929, ix, p. 555.

Here there are suggestions not of grades, planes, or levels, but rather of coördinate aspects of a dignified and important *common service* for *health* maintenance and *health* promotion. Dr. Asgis does not distinguish between "specialty of medicine" and "specialty of medical practice." Dentistry, as now established by statute in the United States and Canada, is plainly a specialty of medicine, if "medicine" is used in its most comprehensive sense as a synonym of *health service*. But dentistry is not a specialty of medicine, if by "medicine" is meant statutory *medical practice*. A dentist is not a physician unless he has been legally licensed to engage in medical practice. No one has been licensed, in the United States or Canada, to practise "stomatology" as something different from dentistry, but as a part of medical practice. Dr. Asgis also systematically ignores the obvious differences in import between "oral specialty of medical practice" and "*equivalent of* an oral specialty of medical practice."

One aspect of Dr. Asgis' uncertainty about the import of the term health service was indicated in a reference to ophthalmology and optometry. The following significant comment in a recent issue (July) of the *American Journal of Ophthalmology*, by Emory Hill, M.D., F.A.C.S., may interest Dr. Asgis; I am sure it will concern the dentists and laymen who have noted traditional and current tendencies in medical education:

". . . . Perhaps the chief defect of [our] preparation in ophthalmology [in medical schools] is inadequate training in refraction, *although refraction is of supreme importance concerning a large majority of those who consult ophthalmologists.*" (Page 572; italic not in the original.)

". . . . He is an exceptional individual who can learn to do first-rate refraction in less than a year of constant work under the guidance of an expert. Yet this is just the class of work which is too often considered elementary [by the ophthalmologist], and many a man [ophthalmologist] who calls for help when confronted by other difficulties *would be ashamed* [*sic*] *to ask for consultation on a refraction case.* I would suggest that this situation needs most frank and honest consideration by our societies. We may ridicule the optician [optometrist], we may damn him eloquently and we may deplore his persistent efforts to gain legal recognition, *but we shall not make headway in solving the real problem, namely how to care for the eyes of the public, unless we as a profession* [*ophthalmologists*] *do consistently*

better refraction work than he does" ["optician," optometrist]. (Page 573; italic not in the original.)

The facts in the foregoing quotation were among the many at the foundation of the general conclusions of the study of dental education, including these (Bulletin on Dental Education, p. 239):

"The unusual mechanical and esthetic demands upon dentistry have fully justified and continue to require its active development as a separately organized profession."

"The long continued indifference of medicine to the development of dentistry, and to the treatment of the abnormalities and diseases of the teeth and oral tissues, suggests that if dentistry were called stomatology, and included in the practice of conventional medicine, the mechanical and esthetic factors of oral health-service would not attain their most desirable improvement and development."

(3) In stating the object of the Dental Faculties Association of American Universities, Dr. Asgis quotes from the compilation published nearly two years after the Association had been amalgamated into the American Association of Dental Schools. The statement of the object of the Association, as made in the constitution, does not refer to dentistry as a "specialty in medicine" (medical practice), but remaining substantially the same from the time of the adoption of the constitution in 1909 to the latest revision in 1922, reads as follows (*Proceedings*, p. 123):

"The object of the Association shall be to promote dental education in accord with university ideals; to improve the standard of preliminary education required for admission to dental schools; to establish reciprocal relations with its members; to establish a national standard which may serve as the basis for a reciprocal interchange of dental licenses among the several states; and to initiate such other activities as from time to time seem advisable."

(4) In alluding to "several outstanding events that led to the [Carnegie Foundation's] inquiry into dental education," Dr. Asgis suggests that "familiarity with dental educational history and the history of our specialty since 1900 will be most helpful." He then refers to a number of events, and makes this statement:

"For ten years this organization [Dental Faculties Association of American Universities] endeavored to have an impartial study of dental education made and on May 7, 1921, according to Dean Smith's report at the fourteenth annual meeting of the 'D.F.A.A.U.' (held on January 22, 1922), Dr. Pritchett approved of the request of the 'D.F.A.A.U.' and agreed [*sic*] that a survey would be made."

Dean Smith's report referred, however, to a conference with Dr. Pritchett months *after* the study had been begun, and also *after* it was known to all of the dental schools and to the members of Dean Smith's committee that it had been inaugurated. President Pritchett's invitation to the present writer to conduct the study was received on January 13, 1921, the study having been previously authorized at a meeting of the Executive Committee of the Trustees of the Foundation. The study is referred to in the Annual Report for 1920–21 as follows (page 5): "*At the request of a number of organizations in the field,* the [executive] committee authorized a study of Dental Education" (italic not in the original).

(5) My "proposal to the 'D.F.A.A.U.' to consolidate" with other bodies in the American Association of Dental Schools was identical with that to the three other associations directly concerned, as is shown by the record from which Dr. Asgis quoted. *The new organization was so constituted that constructive leadership could be exercised to greater general advantage than in or through the individual bodies separately.* The union was unanimous, cordial, and without reservation. Dr. Asgis considers that "a most progressive vitalizing force in the dental educational world came to an end" when the university members of the "D.F.A.A.U." became members of the American Association of Dental Schools. His reason for this view is not evident, because the new Association affords abundant opportunity for the persuasive presentation of plans and ideals, and has all of the educational aims of the "D.F.A.A.U." and more. The objects are stated as follows in the constitution that was adopted by unanimous vote of all concerned, including the representatives of the "D.F.A.A.U," and which has not been amended:

"The American Association of Dental Schools has been established to facilitate intercourse and conference among *teachers* of the dental sciences

and arts in North America; to promote advancement of *teaching* and research in American schools of dentistry; to encourage thorough study and discussion of the needs and problems of dental education; to improve public understanding and appreciation of the quality and value of dentistry; and to maintain dental education in full accord with the highest requirements of professional education in the public service." [Compare with the objects stated on page 597.]

When the four national bodies were consolidated in the international American Association of Dental Schools, nobody suggested that one of the new organization's objectives should be the conversion of dentistry into a specialty of medical practice, although there was unlimited opportunity for free expression of opinion and desires.

(6) It is puzzling to find in Dr. Asgis' report the misstatement that, since "the influence" of the Dental Faculties Association of American Universities "came to an end," the Dental Educational Council has been "the only and official guide in dental educational policies." The American Association of Dental Schools, into which the "D.F.A.A.U." was amalgamated in 1923, has met annually since and publishes a yearly volume of Proceedings. All of the schools previously members of the "D.F.A.A.U." are members of the "A.A.D.S.," where they are as free as all others to exercise their "influence." They have evidently been doing so. This may be inferred from the respect shown their representatives. There were only 13 schools in the "D.F.A.A.U." when it "came to an end," but there were 43 in the "A.A.D.S." at the last meeting. Yet of the seven present elective officers and executive committee, the president-elect and two members of the executive committee are deans of schools formerly members of the "D.F.A.A.U." Two more of the seven are deans of dental schools in state universities, one is the dean of a university school in Canada, and only one is a teacher in an independent school.

(7) It is said, in Dr. Asgis' comment, that "the Gies study has, apparently, not dealt with the facts of dental practice, of the economic and professional needs, of the rank and file of practitioners of today," etc., and therefore "it cannot be said to have dealt with the *broad dental educational problem*, in the sense in which medical educational problems are approached." But the truth is that for six years these facts, needs, and conditions were carefully examined and, as many dentists

know, are included in the back-ground of the study, and account for many statements and conclusions in the Bulletin on Dental Education. If Dr. Asgis will take the trouble to compare the Carnegie Foundation's Bulletin on Dental Education with its Bulletin on Medical Education, he may be inclined to believe that these matters were not given less attention in the former than in the latter. Just how a study of professional education could be conducted without basing it on the most important facts relating to the practice of the profession is not evident. If these facts had been ignored, the omission would have been noted by others long ago.

Dr. Asgis further persuades himself to be satisfied with this derogatory comment by minimizing the significance of the acknowledged coöperation of the dental profession, seeming to think that only the "leadership" of the dental profession was consulted—only "representatives of the American Dental Association, Dental Educational Council, dental schools, and related bodies." But in this he is greatly mistaken, for there was free intercourse with the rank and file of the dental profession in all parts of the United States and Canada. He did not seem to notice this acknowledgment (Bulletin, page 241): "The study has also been furthered by very helpful advice received from a large number of teachers in medical schools, experienced students of education, members of state boards of examiners [medical and dental], officers of hospitals, and members of boards of health, who responded cordially to all requests for counsel." At one place in Dr. Asgis' report, however, where his purpose is furthered by some comment of mine, he says that "the 'poor boy' argument against higher standards for dental education . . . received fair treatment in the Bulletin . . . This is a most commendable progressive step on the part of Prof. Gies." But could this "step" have been taken in the dark—in ignorance of important economic conditions of dental practice?

In this connection Dr. Asgis expresses the opinion that I am unable to understand and properly to discuss dental education, because I have not practised dentistry, and that *therefore* the findings and recommendations in the Bulletin do not cover essentials. But he does not seem to be concerned about the correlative deduction that, if this is true, then it follows that he himself is not able to understand and

properly to discuss medical education or any specialty of medical practice, because he is not a physician and has not been licensed to engage in statutory medical practice or in any specialty of it. I do not express this as my belief, but it must be correct if Dr. Asgis' position regarding my deficiency is warranted.

(8) Dr. Asgis, alluding to the general conclusions in the Bulletin on Dental Education, considers it "quite important to ascertain whether these 'conclusions' were arrived at as a result of the facts gathered." He then insinuates: "We know from records available that the main conclusions, in principle, were presented before the issuance of the Bulletin in 1927." An array of such statements is open to false implications. Having visited every dental school in the United States and Canada at least once in 1921–22, and most of them at least once again in 1922–24, and meanwhile having conferred with many dentists, physicians, and others on the facts and conditions of dental practice, medical practice, dental education, and medical education, I publicly stated provisionally some of the main conclusions of the study, *in order to subject the chief findings to critical analysis and to the light that further information and broader vision might focus upon them from all sides.* The first public statement was made in an address at Cleveland, in September, 1923; the second, in an address at Chicago, in March, 1924. Both addresses were promptly published in the *Journal of the American Dental Association* and the *Proceedings of the American Association of Dental Schools*, respectively. On this program of frank publicity, the conclusions as published in the Bulletin on Dental Education had been put under the close scrutiny of all who were disposed to point out fallacies in them. In 1923–26 I spent three earnest years in incessant further discussion of the facts and conditions of practice and education on which these public preliminary statements were based, in order to phrase all the conclusions finally in complete accord with the realities on which they are predicated. That the reader may have these "general conclusions" close at hand, for comparison with Dr. Asgis' comment and the remarks above, they are quoted below (Bulletin on Dental Education, pp. 239–40):

"Dentistry is an important division of health service relating directly to the teeth and closely adjacent oral tissues, and indirectly to other parts of

the body, to the organism in general, and to the transmission and prevalence of some communicable diseases.*

"Dentistry, in the quality and efficiency of its service to the patient, should be made the full equivalent of an oral specialty of the practice of medicine.

"The unusual mechanical and esthetic demands upon dentistry have fully justified and continue to require its active development as a separately organized profession.

"The long continued indifference of medicine to the development of dentistry, and to the treatment of the abnormalities and diseases of the teeth and oral tissues, suggests that if dentistry were called stomatology, and included in the practice of conventional medicine, the mechanical and esthetic factors of oral health-service would not attain their most desirable improvement and development.

"The success with which dentists have brought dentistry to its present state of usefulness, appreciation, and opportunity, against persistent belittlement as 'merely a mechanical art,' and the strength of the evolution of its scope and function now plainly in progress, indicate unmistakably that the leadership of the dental profession is advancing dentistry toward its full possibilities in health service.

"Dentistry can be effectually and economically developed to the full service equivalence of an oral specialty of the practice of medicine through extension and improvement, in universities, of that system of dental education which, though separate from medical education, is closely related to it and should be more intimately associated with medical schools, hospitals, and dispensaries.

"This extension and improvement could be accomplished without requiring the prospective general practitioner of dentistry to become a doctor of medicine before beginning his dental training, and could best be brought about by pursuit of the following three main objectives: (*a*) the preliminary education and the instruction in the medical sciences should be practically the same in general scope and quality as for medicine; (*b*) the technical and clinical training, the applications of the medical sciences, and the correlations of clinical dentistry with clinical medicine should be

*" Throughout this Bulletin 'health service' is used in its natural sense to signify any and all private and public means to maintain or to promote health, to prevent disease, to restore health by treatment and cure of sickness, and to alleviate the discomfort, distress, and disability of incurable ill-health. Public-health administration, education for the prevention of disease, medicine, dentistry, nursing, and pharmacy are important divisions of health service."

sufficient to assure both ability to initiate safely a dependable modern general practice of dentistry and capacity to grow in proficiency; and (*c*) the most advanced phases of dental practice should be reserved for systematic graduate study.

"These three objectives could be attained through the requirement of at least (*a*) two years of approved preparatory work in an accredited academic college, including several extra courses that would stimulate interest and develop ability in the prospective practice of dentistry, or reveal ineptitude, (*b*) and three years of intensive and well-integrated effort in an undergraduate dental curriculum for the training of general practitioners only, the years to be lengthened by beginning them with summer sessions, or otherwise, wherever the time equivalent of four professional years of conventional length is regarded as essential; followed by (*c*) optional supplementary full-year graduate curricula for advanced training, during one or more years, in all types of dental and oral specialization. The suggested lengthening of the dental years, which might be accomplished by their subdivision into "quarters" in the conventional manner, would prevent long interruptions in the digital training besides adding a year to the practitioner's career in practice. Loan funds could be used to aid students in need of financial assistance.

"Such a reorganization, by its selective character in the preparatory education, by its establishment of broad health-service objectives, and by its placement of the oral specialties on a graduate basis, would raise dentistry to intellectual equality with medicine, and would give physicians and dentists analogous types of professional training. It would develop similar capabilities in medical comprehension, ensure mutual respect and understanding, and facilitate intimate coöperation in the promotion of the welfare of patients.

"This general improvement in dental education would involve reconstruction of the dental curriculum, with special reference to important betterment of the teaching in all of its aspects; economy of time without impairment of the efficiency of the instruction in the medico-dental sciences, in dental technology, and in clinical dentistry; more useful application of the medical and technical sciences; and more advantageous correlation of clinical dentistry with clinical medicine.

"The proposed regeneration of dental education would necessitate, in practically all of the dental schools, an increase in the number of well-trained, whole-time teachers, especially in the dental subjects; and also great improvement of the libraries, and active advancement of research.

"The dental schools in this country and in Canada, lacking endowments

and in most cases being obliged to keep the quality of their work to the level of their income from fees, will be unable to proceed with the suggested improvements unless, individually, they receive large gifts of funds for the purpose.

(9) Dr. Asgis asks: "Who was the study prepared for?" And concludes: "I cannot say, and leave this question unanswered." I am glad to answer the question. The study was conducted, "at the request of a number of organizations in the field," under the auspices of a disinterested educational foundation, with the coöperation of many qualified persons, by a member of a university faculty of medicine. The one in charge of the study was given the public responsibility and complete freedom to ascertain the whole truth relating to dental education, to state it judicially and independently, and to offer recommendations to advance the public interest. The study was conducted like any other inquiry in which I have engaged since first receiving, in 1893, practical instruction in the ways and means of *unprejudiced* research. That I disagree with Dr. Asgis may be due to the fact that I am more concerned about the furtherance of public interests than of partisan professional purposes. In 1924 I said: "Dentistry is neither a political party nor a secret society. It is not an organization of dentists, conducted by dentists, for dentists. Dentistry is an accredited agency for public service, open to public inspection, subject to public regulation, and subservient to enlightened public opinion."

(10) Dr. Asgis quotes me to the effect that the "American Stomatological Association . . . . does not appear to be receiving any *marked encouragement* from either dentistry or medicine" (italic not in the original). Dr. Asgis then says of this comment that it is difficult for him "to understand how it can be said that the [stomatologic] movement received *no support* from either medicine or dentistry," etc. (italic not in the original). I did not say the Association received *no support*, but referred only to the absence of "*marked* encouragement."

What Dr. Asgis repeatedly calls the "stomatologic movement in America," which he originates in his own activity, was not the radiant reality in my observation that it appeared to be in his imagination.

During the preparation of the report on dental education, the "movement" did not seem to be imposing to one who did not wish to be imposed upon, although I carefully inquired into its import. The reader of Dr. Asgis' intimations might be inclined to assume that prejudice or an unworthy purpose accounts for several related omissions from the Bulletin, each of which at one place he calls "important," later admits is "perhaps unimportant", but again regards as being collectively significant. Yet the reasons for these omissions are very ordinary. After a trial for over forty years, the American Medical Association had recently discontinued its Section on Stomatology. This important occurrence, and one associated with it, were referred to briefly as follows on page 5 of the Bulletin on Dental Education:

"The Section on Stomatology of the American Medical Association, established in 1881 to make the relationship between medicine and dentistry more intimate, was disbanded in May, 1925, chiefly because of lack of medical interest in dentistry. The American Stomatological Association, founded in October, 1924, aims to convert dentistry into a specialty of the practice of conventional medicine, but does not appear to be receiving any marked encouragement from either dentistry or medicine."

Neither of the two general statements of fact, in this quotation, left much to be said for a "stomatologic *movement* in America," when the report to the Foundation was written. At that time (1926) I was unable to obtain a public list of the members of the American Stomatological Association. As this organization appeared to be in fact a "paper constituent"[2] of the Association Stomatologique Internationale, which also seemed to have no significant influence on dentistry in the United States and Canada, the "A.S.I.," with numerous other matters equally distant in relationship, was not mentioned. Even with many such omissions, the Bulletin contains more than 700 pages (xxi + 692). Dr. Asgis, in his report, does not refer clearly to the present difference between the American Stomatological Association, which he founded, and the American Society of Stomatologists,

[2] This general characterization of the American Stomatological Association (in 1926), which accorded with current opinion, is quoted from comment, in response to inquiry, by one who was repeatedly said to be among the Association's representative members.

to which he presented the report under discussion; nor does he indicate which now represents the "movement" in the "A.S.I." and why.

Dr. Asgis wrote: ". . . . the Bulletin [on Dental Education] does not represent the stomatologic viewpoint." This statement is correct if he means that the Bulletin reflects disinterested opinion that did not find it possible to agree with some ideas expressed by himself and others before him. The Bulletin is not a partisan publication. In this Dr. Asgis has evidently been disappointed. Here the reader may be suitably referred to this comment on page 589 of Dr. Asgis' report: "The American Society of Stomatologists . . . . must under no circumstances surrender any of its rights and privileges bestowed upon it by virtue of its position as a defender of the welfare of the rank and file of the dental profession." Delusions of grandeur are not always serious symptoms—they frequently indicate merely the lack of a saving sense of humor.

Dr. Asgis has no reason to assume that the merits of the "stomatologic movement" were not given careful attention. In his introductory note he refers to conference and correspondence between us, which related to the "movement." On page 616 of the Bulletin on Dental Education appears the following direct reference to this matter:

> "Recently in Quebec, and here and there in the United States . . . . there has been a revival of interest in the idea that dentistry should be converted into a specialty of the practice of conventional medicine, and also in the proposal that a full education in medicine and graduation with the M.D. degree should be made prerequisites to the study of dentistry. These views, although never approved in North America, *have been discussed frequently during the past century.* They were given earnest consideration throughout the present study. *The reasons for the writer's dissent are indicated in the Introduction, and in Chapters VII and X, of this Bulletin.* When dentistry, continuing its separate organization and its own system of training and practice, becomes *the full service equivalent* of an oral specialty of medicine. . . . , *the public will have no interest* in the technical question whether dentistry should be formally converted into a specialty of the practice of conventional medicine." (Italic not in the original.)

In this quotation, the reference to "the public" indicates "for whom"

the present writer believed, to revert to one of Dr. Asgis' questions, "the study was prepared."

11. Several miscellaneous matters, of many that need correction, may be briefly considered together. Dr. Asgis, in his introductory note, refers to the acceptance of his report for publication in this *Journal* as an indication that its pages have been "opened" to a discussion of "a phase of the stomatologic movement." The *Journal* has never been closed to any subject of interest to dentists. His report was accepted for publication, despite its misstatements, verbosity, and attenuation, because the managing editor is never protected by the *Journal* against public criticism. If, however, Dr. Asgis' report, in its present form, had been aimed at the efforts of any other person, the report would not have been accepted, since it adds nothing that is sufficiently important for the promotion of oral health-service to justify the expense of publication or the cost of exposing its numerous inaccuracies and fallacies.

Referring to the report on dental education, Dr. Asgis said: "This study is a report by Professor Gies *to* the Carnegie Foundation . . . . and not a *Carnegie* Report." No reader would have drawn an erroneous impression if Dr. Asgis had added that the Bulletin containing the report is a special *Carnegie* publication, and that the conclusions of the study have been endorsed in Annual Reports of the Carnegie Foundation.

Dr. Asgis alludes to ineffectual attempts to "consolidate" the Dental Faculties Association of American Universities "with the Dental Educational Council." This indicates a misconception of the nature and functions of these organizations. Perhaps Dr. Asgis refers to negotiations for the appointment by the "D.F.A.A.U." of representatives in the Council.

In quoting from minutes relating to the consolidation of the "D.F.A.A.U." with other bodies in the American Association of Dental Schools, Dr. Asgis wrote that "Dean Smith of Harvard was opposed to such an amalgamation." This statement would have been more completely accurate if it had indicated that Dean Smith was the *only one* recorded as opposed to it—that (quoting from the *Proceedings*, p. 114) "a *letter was read* from Dean Smith of Harvard in which he expressed himself as opposed to such an amalgamation." The

Proceedings show that, owing to illness, Dean Smith was unable to participate in the discussion of the motion to amalgamate. Dr. Asgis, to prevent misunderstanding, should have alluded to related comment in the *Proceedings* indicating that "it was agreed" that "*no one doubted that consolidation would take place as proposed,*" and that a committee of five was appointed to proceed with arrangements to that end. All of the "membership universities" except Harvard were represented at the meeting.

Dr. Asgis suggests the use of "the term 'dental autonomy' as a synonym of 'dentistry' and 'oral health service'." If I were to advise the use of the term "medical autonomy" as a synonym of "medicine" and "health service," Dr. Asgis would surely regard the idea as nonsensical. But it would be just as logical and appropriate as Dr. Asgis' proposed use of "dental autonomy."

At the conclusion of a summary of "outstanding events," presumed to have had an important bearing on the initiation and outcome of the Carnegie Foundation's study of dental education, Dr. Asgis says that "the historical value of these events in dental educational history is most significant to us" [American Society of Stomatologists]. I should agree with him, if he meant the events as they occurred rather than as he reports and interprets them.

(12) "Psychological (social) and cultural (economic) forces of dental autonomy are so subtly at work in the dental profession," Dr. Asgis says, "that even an astute mind like that of Prof. Gies was unable to detect and to resist their influence, *which colored the data and logically the 'conclusions' of his study*" (italic not in the original). If the comment I have italicized is warranted, it is also important, and the whole truth on which it rests should be stated to the Carnegie Foundation and also published. Dr. Asgis is hereby invited to publish, in this *Journal*, either a revelation of the facts that justify his assertion, or a suitable statement that such facts are not known to him.

Having given attention, above, to several subjects on which it is desirable promptly to comment, I shall discuss in a succeeding issue the proposed substitution of the term "stomatology" for "dentistry," and also the two-three-graduate plan.

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